S-29-41

THE JOURNAL OF ENGINEERING EDUCATION

Published by THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

NEW SERIES
VOL. XXXI., NO. 9 | MAY, 1941 | Subscription Price $3.00 per year
Single copies 50 cents

ANNOUNCING

the new sixth edition of

French's
ENGINEERING DRAWING

By THOMAS E. FRENCH
Professor of Engineering Drawing, Ohio State University

656 pages, 6½ x 9¼, fully illustrated. $3.00

The new sixth edition of this preeminently successful text, which for three decades has been the leader in the field, has been designed to keep the book abreast of the latest advances in engineering and pedagogy and to assure the continuance of its role as a vitalizing and progressive influence in technical education.

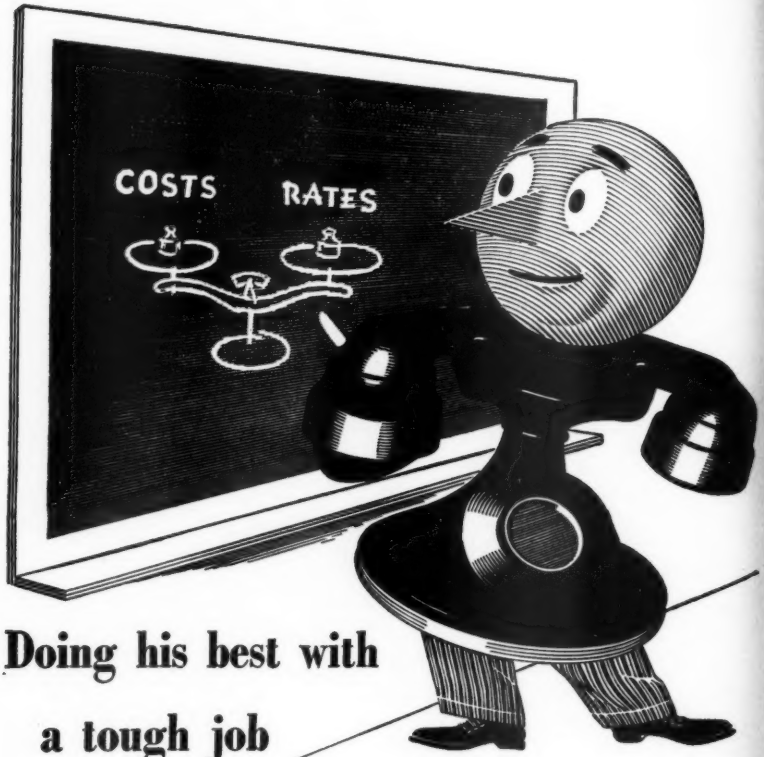
The revision offers the following noteworthy features: the increase in page size permits the use of larger illustrations; all illustrations and problems conform to American Standards Association rules, and are uniform in appearance; the large list of new problems provides fresh material for both beginning and advanced courses; there is a timely new chapter on aircraft drawing, giving the latest procedures and codes of practice in that industry; an important new chapter deals with jigs and fixtures, with modern examples and problems; the chapters on drawing in the shop and on bolts and screws have been enlarged and contain much new material; the chapter on dimensioning has been revised and enlarged; and new material has been included on auxiliary views, cams and gears, and piping.

Send for a copy on approval

McGRAW-HILL BOOK COMPANY, Inc.

330 West 42nd Street | New York, N. Y.

19th Annual Meeting, S.P.E.E., University of Michigan, Ann Arbor, Michigan, June 23–27, 1941



Doing his best with a tough job

The hardest job of the Bell System is to give you more and better telephone service and yet keep rates low. It isn't easy to keep those two things in balance. Increasing costs and taxes make it difficult.

But there is no end to trying. There is never any letting up in the search for a better, more economical way. All along the line, the Bell System believes in economy in business housekeeping. That is part of its obligation to the public.

BELL TELEPHONE SYSTEM

"The Telephone Hour" is broadcast every Monday. (N. B. C. Red Network, 8 P. M., Eastern Daylight Saving Time.)

Announcing

A Price Change of Importance

on Schumann's

TECHNICAL DRAFTING

NEW PRICE $3.00

We are making this reduction in price because we know that the cost to the student is an important consideration and we cannot allow a difference in price to be a determining factor in your selection of a text. There is now no difference in price between Schumann's *TECHNICAL DRAFTING* and other books in the field. But there is a great difference in content: Schumann's text is considerably larger, more fully illustrated, more inclusive, and much more costly to manufacture.

At the same time we are pleased to announce that while the text now contains many illustrations applicable to aeronautical drafting, a new chapter will be available with the text this summer. This chapter will make use of materials and illustrations taken directly from the industry, and hitherto unavailable.

HARPER & BROTHERS, 49 East 33d St., New York

NEW WILEY BOOKS

•

Ready in May

MINING ENGINEERS' HANDBOOK, Third Edition

ROBERT PEELE, Editor-in-Chief, and a Staff of Specialists. In two volumes, not sold separately.

Ready in August

PRINCIPLES OF ELECTRICAL ENGINEERING

By G. F. CORCORAN, Professor of Electrical Engineering, and K. B. KURTZ, Professor and Head of the Electrical Engineering Department; both at the State University of Iowa.

Approx. 450 pages 208 illus. 6 by 9
Probable price, $4.00

Ready in June

AERODYNAMICS OF THE AIRPLANE

By CLARK B. MILLIKAN, Professor of Aeronautics, California Institute of Technology. (Part of the Aeronautical Engineering Series, edited by Theodore von Karman and Clark B. Millikan.)

Approx. 159 pages 103 illus. 6 by 9
Probable price, $2.00

Ready in June

ELEMENTS OF ENGINEERING THERMODYNAMICS, Sixth Edition

By JAMES A. MOYER, Director of the Massachusetts Department of University Education; the late JAMES P. CALDERWOOD; and ANDREY A. POTTER, Dean of the Schools of Engineering and Director of the Engineering Experiment Station, Purdue University.

Approx. 232 pages 80 illus. 6 by 9
Probable price, $2.50

Ready in June

TRAFFIC ACCIDENTS AND CONGESTION

By MAXWELL HALSEY.

Approx. 277 pages Illus. 6 1/4 by 9 1/4
Probable price, $3.50

Ready in July

HIGHWAY CURVES, Third Edition

By H. C. IVES, Civil and Consulting Engineer.

Approx. 553 pages 7 illus. 4 1/4 by 6 1/4
Probable price, $4.00

Ready in July

BELT CONVEYORS AND BELT ELEVATORS, Third Edition

By FREDERIC V. HETZEL, Consulting Engineer, and RUSSELL K. ALBRIGHT, Engineer and Designer, Link-Belt Company.

Approx. 425 pages 303 illus. 6 by 9
Probable price, $6.00

Ready in July

METAL-PROCESSING

By ORLAN WILLIAM BOSTON, Professor of Metal Processing and Director, Department of Metal Processing, University of Michigan.

Approx. 611 pages 503 illus. 6 by 9
Probable price, $5.00

Ready in July

PHOTO-ELASTICITY

By MAX M. FROCHT, Associate Professor of Mechanics, Carnegie Institute of Technology.

Approx. 378 pages 349 illus. 6 by 9
Probable price, $6.00

Ready in September

AMERICAN HIGHWAY PRACTICE, Volume I

By LAWRENCE ILSLEY HEWES, Chief, Western Region, U. S. Public Roads Administration.

Approx. 556 pages 254 illus., 11 folding charts 6 by 9
Probable price, $6.00

Ready in June

RADIO-FREQUENCY MEASUREMENTS By Bridge and Resonance Methods

By L. HARTSHORN.

Approx. 265 pages 99 illus. 5 1/4 by 8 1/4
Probable price, $4.50

Ready in June

ARCHITECTURAL GRAPHIC STANDARDS, Third Edition

By CHARLES G. RAMSEY and HAROLD R. SLEEPER, Associate Architects with Frederick L. Ackerman.

Approx. 337 pages 315 illus. 9 1/2 by 11 1/4
Probable price, $6.00

• **JOHN WILEY & SONS, INC.** •

440 Fourth Avenue **New York, N. Y.**

THE JOURNAL OF ENGINEERING EDUCATION

Published monthly (except during July and August) by the Society for the Promotion of Engineering Education

Published under the Supervision of the Publication Committee.
D. B. Prentice, O. J. Ferguson, F. L. Bishop, Editor, University of Pittsburgh.
Published at Prince and Lemon Sts., Lancaster, Pa.

Entered as second-class matter at the Post Office at Lancaster, Pa., under the Act of August 12, 1912.

New Series
Vol. XXXI, No. 9 | MAY, 1941 | Subscription Price, $3.00 per year. Single Copies, 50 cents

TABLE OF CONTENTS

Inspection Trips at Michigan Meeting 631
Selective Service of Engineering Students 632
Evaluation and Continuation of the Engineering Defense Training Program. Roy A. Seaton 635
Engineers' Council for Professional Development. R. E. Doherty 638
Antiphonal Responses. Gilbert E. Doan 646
Enrolment-Staff Ratios. George C. Ernst 650
Business Training for Engineers. H. B. Cooley 654
Suggestions for Improving Engineering Text Books in Which Coördinates Are Used. E. A. Hertzler 660
M.K.S. Units in Electrical Engineering Courses. Paul L. Morton 668
48th Annual Meeting:
Films and Slides as Aids in Theory Courses. W. R. Bryans 672
Correlation of Courses in Mechanics. J. C. Othus 680
Economics in Mechanical Engineering. Andrew I. Peterson 686
Extension of the Engineering Curriculum and Its Relation to Coöperative Work. R. C. Disque 695
Is Your English Short-Circuited? W. George Crouch and M. L. Manning 700
Sections and Branches 711
Engineering Economy Page 713
Industrial Engineering Page 714
T-Square Page 715
New Members 716
Necrology: R. E. Nyswander 717
Book Reviews 717

HEADQUARTERS OF THE SOCIETY

UNIVERSITY OF PITTSBURGH, PITTSBURGH, PA.

OFFICERS OF THE SOCIETY, 1940–41

President

D. B. PRENTICE, Rose Poly. Inst., Terre Haute, Ind.

Vice-Presidents

L. E. CONRAD, Kansas State College, Manhattan, Kansas.
E. L. MORELAND, Mass. Inst. of Tech., Cambridge, Mass.

Secretary

F. L. BISHOP, University of Pittsburgh, Pittsburgh, Pa.

Treasurer

W. O. WILEY, John Wiley & Sons, New York City

Assistant Secretary

NELL MCKENRY, University of Pittsburgh, Pittsburgh, Pa.

SECTIONAL MEETINGS

ALLEGHENY—The Pennsylvania State College, November, 1941.
INDIANA-ILLINOIS—Northwestern Technical Institute, 1942.
NEW ENGLAND—Dartmouth College, October 18, 1941.
NORTH MIDWEST—University of Wisconsin, October 11–12, 1941.
ROCKY MOUNTAIN—University of Wyoming, May 2, 1942.
PACIFIC SOUTHWEST—Fresno State College, December 29–30, 1941.

INSPECTION TRIPS AT MICHIGAN MEETING

"We are planning for Thursday afternoon, June 26, a trip through the General Motors Proving Ground, the Chrysler Engineering Laboratories and the Plymouth and Ford Motor Companies. I have a letter from the Chrysler Laboratories stating that they must have, at least a week in advance, the names and connections of those who will make the trip. This, of course, is because of the amount of defense work which is being carried on. Chrysler Laboratory is the only one who has mentioned a restriction of this sort, but the condition is likely to grow worse instead of better. It seems to me, therefore, that it would be very wise if there was put into the general announcement a statement that those who plan to take the trips which we have arranged should supply the local committee with their names and connections ten days prior to June 26."

This information was received too late to include in the preliminary program. If you expect to take any one of the above inspection trips will you notify Professor Charles B. Gordy, Chairman, Committee on Trips and Excursions, University of Michigan, Ann Arbor, Mich., not later than June 16, 1941, so that he may notify the companies concerned.

F. L. Bishop, Secretary, S. P. E. E.

SELECTIVE SERVICE OF ENGINEERING STUDENTS *

In Bulletin No. 10 it was stated that a letter identifying areas for individual occupational deferment would be sent by National Headquarters, Selective Service System, to state directors for transmittal to all local boards. The following letter was mailed on April 21 by Brigadier General Hershey:

MEMORANDUM TO ALL STATE DIRECTORS

SUBJECT: OCCUPATIONAL DEFERMENT OF STUDENTS AND OTHER NECESSARY MEN IN CERTAIN SPECIALIZED PROFESSIONAL FIELDS

Part I: Office of Production Management Findings and Policy.
Part II: Procedure on Student Deferments.

Part I: Office of Production Management Findings and Policy. —The following letter to the Deputy Director has been received from the Associate Director of the Office of Production Management:

"From studies which I have asked the Bureau of Labor Statistics to make, I conclude that the supply of manpower in the specialized professional fields listed below, which have a definite and direct relationship to the national defense program, is at a dangerously low level. It is necessary that this level be raised by every means within our power. Certainly the flow of trained graduates into these fields should not be unnecessarily interrupted by the action of any agency of Government. It is my conclusion that the national interest requires that students be encouraged to continue their education in these fields and that the principle of occupational deferment under the Selective Service program may be used to assure their future availability to all activities relating directly or indirectly to the national defense program.

"The Bureau of Labor Statistics has been represented at various conferences in discussing this general problem and has, on its own initiative, interviewed responsible people important in the special branches of the professions, with a view to getting a cross section of opinion on the matter. It is reported that the uncertainties arising from the attitudes of local draft boards have already affected the registration of students for graduate work in the pro-

* This information was transmitted in Bulletin No. 11, American Council on Education.

fessional fields. *Therefore, it is urgently recommended that the most serious consideration be given by the Selective Service System to the individual occupational deferment of students in the following courses, so long as they continue to be in preparation or training as necessary men in activities necessary to the national defense:*

Chemistry
Engineering
- Civil
- Electrical
- Chemical
- Mining and Metallurgical
- Mechanical

"The above occupations have been especially studied by the Bureau and a *dangerously low level of manpower is found to exist therein.* Therefore, the immediate attention of Selective Service is requested to the problem preventing any unnecessary increase of these shortages so that the national defense program will not be impeded unnecessarily.

"The following are professional occupations in which authorities allege that a shortage will exist, but which have not yet been studied by the Bureau. However, there is complete agreement among representatives of industry, of American colleges and universities, and of the practicing professional groups that the present and future demands of the national defense program for college-trained scientific personnel will transcend the normal supply of graduating students that comes onto the labor market at the close of the academic year.

Engineering
- Agricultural
- Sanitary

Dentistry
Pharmacy
Physics
Medicine
Biology and Bacteriology
Geology
- Geo-Physics
- Meteorology
- Hydrology
- Cartography

"The result of further research, as it becomes available, will be transmitted to you as a supplement to this present report."

It is directed that this release be disseminated to all local Selective Service agencies in your State as an expression of the national policy in these fields.

In applying these broad provisions there must be no deviation from the clear statutory prohibition against group deferments. The local board has full authority and responsibility, subject to appeal, for deciding whether or not a registrant is a necessary man and whether he should be selected or deferred. It must consider

all the evidence submitted in connection with each individual case and must decide each case on its particular facts.

Part II: Procedure on Student Deferments.—Local boards should approach the immediate problem of reclassification of those students whose order numbers have been passed over because of the temporary student deferment provided for in Paragraph 345 of the Regulations and the problem of original classification of those students who are now receiving their questionnaires, with due regard to the national policy as expressed in Part I.

In order to assist local boards in applying the broad provisions of the above policy and general findings of fact to individual cases, a suggested procedure for presenting detailed facts to local boards having jurisdiction of cases of individual students has been prepared by the American Council on Education and concurred in by National Headquarters of the Selective Service System.

This procedure is set out in detail in the American Council on Education's Bulletin No. 10, sufficient copies of which are being forwarded to your headquarters under separate cover to allow for a distribution of one per local board. In brief this procedure provides for getting into the hands of the local board a "Student Statement of Information" presenting the student's statement of his status and plans, and an "Affidavit of the College or University" in which the college officials testify as to the student's standing, courses and occupational objectives, together with a general evaluation of the student as a "necessary man." This information should be considered by the local board in the same manner as a Form 42 in other occupational deferment cases.

It is requested that State Directors coöperate with colleges and universities in their respective States so that uniformity of operation may be attained. Similarity of procedure will be of mutual advantage.

LEWIS B. HERSHEY,
Deputy Director

Interpretation: It is our opinion that it will be necessary in the interest of national defense to grant occupational deferment to a bona fide student in a recognized college or university in any of these professional fields. This includes the individual student in an undergraduate preprofessional course and the student who graduates this June and is enrolled for admission this September in a professional school offering training in these fields, provided the college or university authority certifies that he is in good standing, gives evidence that he will satisfactorily complete his course and will enter the profession.

EVALUATION AND CONTINUATION OF THE ENGINEERING DEFENSE TRAINING PROGRAM

By ROY A. SEATON *

The U. S. Office of Education is now confronted with the problem of planning the future extent and direction of Engineering Defense Training. For assistance in solving this problem it recently asked representatives of participating engineering schools for reports on their experience with the program during the past few months of actual operation.

On March 21, 1941, letters were sent to all institutional representatives, regional advisers, and members of the advisory committee asking the following questions:

1. What is your evaluation of the present Engineering Defense Training program?
2. Does the situation in your area justify continuation of Engineering Defense Training through the next fiscal year and, if so, on what scale?
3. Would the facilities at your institution permit a more extensive program next year than that currently in progress? If so, to what extent?
4. What is your estimate of the number of students your institution would expect to train in the next fiscal year (July 1, 1941 through June 30, 1942) if funds are forthcoming for a continuing program?
5. Do you have any suggestions as to ways in which the Engineering Defense Training program might be made more effective?

Those addressed were urged to discuss these questions with the presidents of their institutions, fellow staff members, and representatives of industry before answering them, in order that their answers might reflect as nearly as possible the considered judgment of both the institutions and the defense industries being served.

Up to April 15, 1941, replies had been received from 117 institutions, many of them supported by letters from officers of industrial concerns, Government agencies, students, and teachers. The replies may be summarized as follows:

* Dean of the Division of Engineering and Architecture, Kansas State College, absent on leave to serve as Director of Engineering Defense Training in the U. S. Office of Education.

1. *Evaluation of the present Engineering Defense Training program*

102 approved the present program; most of them, quite heartily; many, very enthusiastically;
11 made no evaluation (Classes just starting);
1 made no evaluation (No reason stated);
1 made no evaluation ("Extension courses will do the work");
1 made no evaluation (No courses yet being offered);
1 reported unfavorably (Could not place men).

2. *Continuation of Engineering Defense Training program during the next fiscal year*

108 favored continuation either at the present rate, at an expanded rate, or with no statement as to rate;
2 were not yet offering courses and did not answer the question;
3 were doubtful as to desirability of continuation of the program in their institutions;
4 did not favor continuation of the program in their institutions.

3. *Expansion of Engineering Defense Training program in the next fiscal year*

83 stated that they could expand their present programs. Of these,
2 considered expansion in their institutions unwise;
1 doubted if expansion would be wise;
3 doubted if they could secure sufficient students;
1 doubted if it could secure sufficient teachers.

4. *Estimates of numbers of Engineering Defense Training students next year*

The figures reported are in so many different forms that it is not feasible to give any numerical summation of them. The replies make it clear, however, that a large increase in full-time students and a small increase in part-time students may be expected through the summer months. For next fall and winter the indications point to a much larger enrollment of part-time students and a slightly larger enrollment of full-time students than at present.

5. *Suggestions for making the Engineering Defense Training program more effective*

A great many suggestions were made, both by the institutional representatives, and by industrialists whose letters were enclosed with the reports. While the suggestions cover so wide a range that it is impracticable to summarize them, a few examples will indicate their general import.

Several institutions and industrial concerns feel that the part-time in-service courses now being given in their areas impose too heavy a burden upon students who have full-time employment. They recommend fewer class hours per week with more home study, even though this may result in extending the length of the courses.

A number of institutions and one manufacturer report that a lack of qualified instructors is hampering the program, and suggest the development of some form of teacher training.

Another suggestion is that Engineering Defense Training applicants be more carefully selected, in order that class groups of a more homogeneous character be secured.

Many letters stress the need for more full-time pre-employment training to develop new technical personnel. Specifically, more Engineering Defense Training courses should be designed for both the non-engineering college graduate, and the high school graduate who is unable to take the full engineering curriculum. Colleges in the non-industrial regions, it is pointed out, should supply many technically-trained workers for the industrial areas.

From a number of sources comes the suggestion that, because of the shortage of engineers, aid should be extended to regular undergraduate engineering students to enable them to complete their training. Both financial assistance and draft deferment were mentioned. One dean suggested that all regular engineering students be drafted immediately and be assigned to their respective colleges until graduation.

While some of the suggestions were conflicting, due perhaps to varied local conditions, and others may prove to be impracticable, all of them will receive careful consideration.

It is evident from a study of the replies to the questionnaire (1) that the great majority of the coöperating engineering schools heartily approve the present Engineering Defense Training program and favor continuation of the training during the next fiscal year upon a considerably expanded scale; (2) that they believe the training is very satisfactorily serving its purpose, but the need for the training will continue to grow with the expanding program of defense activities; and (3) that the experience with the program this year will point the way to numerous improvements in the program for next year.

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

A Report to the Boards of Constituent Bodies by the Chairman of the Council

I. E. C. P. D. Should Look Ahead

The engineering profession faces a great challenge and opportunity. It faces the imperative challenge of the unstable new world it has helped to create, and the opportunity to take a hand in stabilizing that world. But if it plans to meet this clear obligation and assume such a role in the life of the country, it should look ahead, measuring the implied responsibilities alongside its capacities for discharging them. Doing this, it would find one fundamental deficiency to be in the capacity for joint action, and another in the character and extent of the engineer's preparation. It is my conviction that these deficiencies are vital and that concerted thought must be given to their correction; otherwise the profession will probably receive and justly deserve the unhappy distinction of having let its next generation down and failed in its national mission.

Most engineers now recognize, I think, that their profession does have a heavy responsibility in the accomplishment of national stability, but they evidently do not realize that the profession is not yet fully prepared for that responsibility. I urge that it promptly address itself to the task of becoming better prepared, and I submit that there are definite ways in which E. C. P. D. should contribute to that task. At the same time, I realize that this contribution cannot be effectively made until the constituent groups reach a clearer understanding and persuasion than they now have as to E. C. P. D.'s purposes and potential usefulness.

I have mentioned capacity for joint action. The constituent bodies have of course demonstrated that they can coöperate. The formation of E. C. P. D. itself is evidence. On the other hand, there is also convincing evidence that professional coöperation has been impracticable. The termination of the American Engineering Council is an instance. The point seems to be that the groups cooperate when it is clear that it is worth while to them individually, and they don't if it isn't.

The question can reasonably be pressed, I think, whether this is now a sufficiently comprehensive attitude. Perhaps it was in an

earlier period. Today, however, when problems of the engineering profession as a whole are crying for solution, when on all sides of national life extravagant insistence upon self-sufficient independence is creating centrifugal forces that tend to disrupt America, engineers must not, I urge, stand by in an indifferent isolation. They have responsibility; whether they would be or not, they are inevitably involved in both general professional and national interests, as well as in the interests of their own particular group. Clearly they should promote the solidarity of the profession so that it may be in position to deal effectively with its own general problems, but especially so that it may take a more vigorous and constructive interest in the common cause of preserving a democratic future for this country.

Constructive coöperation is at the heart of democratic life. For democracy, if I understand it, is not merely an aggregation of groups in several realms such as the political, industrial, professional. Rather it is a *system* in which these parts are *organically* related to the whole, and in so far as such a relationship does not exist, the basis for national stability does not exist. And this is the primary reason why the groups of the engineering profession should cultivate the capacity for coöperation.

The second deficiency I have mentioned is in the character and extent of professional training. To promote the professional status of engineers is to promote the effectiveness of the profession. This means better selection of engineering students, more appropriate collegiate training, increased opportunity and incentive for the engineer to continue his education after graduation, and fuller recognition of professional achievement. The full accomplishment of such a program of professional development certainly requires a coöperative effort.

There are undoubtedly other fruits of professional coöperation and other ways of coöperating, but I have outlined a way in which the profession can go ahead. For the purposes involved are precisely those of E. C. P. D.

Thus what I am urging is that the constituent organizations of the Council take a greater democratic hand in the affairs of this conference body which, with wisdom and vision, they set up about eight years ago. But I know that before greater professional interest is taken in the present work and the possible further usefulness of the E. C. P. D. in the future, the members of the constituent bodies must understand much better than they do now just what E. C. P. D. is. Some think that it is merely an accrediting agency for engineering curricula; others are aware that it has additional functions but feel that it has accomplished little except in the field of accrediting; a great many fear that it is ambitious to become a

superbody which may try to usurp powers of the constituent Societies; and there are, of course, those who do not know or care what it is all about. Then there may be others I have not heard from. So there should be an educational campaign by the several engineering groups to acquaint their memberships with the purposes and work of the Council.

E. C. P. D. is what its charter says it is. This charter is a great document of engineering statesmanship that clearly points the democratic way toward the further development of the solidarity and prestige of the profession. It says, "The E. C. P. D. is a conference of engineering bodies organized to enhance the professional status of the engineer through the coöperative support of those national organizations directly representing the professional, technical, educational, and legislative phases of an engineer's life." To this end it aims to "coördinate and promote efforts and aspirations directed toward higher professional standards of education and practice, greater solidarity of the profession, and greater effectiveness in dealing with technical, social, and economic problems."

Thus E. C. P. D. is immensely more than an accrediting agency. True, as such an agency it has been eminently successful in doing an extremely difficult job that might, in less able hands, have ended in confusion. In comparing this with other Council projects, however, one should remember that whereas the completion of an accredited list of curricula is the kind of assignment that can be carried out in a few years, the purposes involved in other projects are most of them of a kind that cannot be achieved promptly; they look to the long run and require continuing negotiation, study, and research. Hence the current results of the other projects, however important they may actually be, do not appear spectacular. But this fact should not be misinterpreted. These projects conceivably may be in the long run even more important to the profession than accrediting.

In the approach toward the goals of E. C. P. D., the value of new sources of counsel and support is obvious. A significant advance was made last October when the Engineering Institute of Canada was welcomed into the Council as a constituent member. This new expression of common interests with Canadian engineers will afford a liaison which will assure the fullest development of those interests in both Canada and the United States as they relate to the purposes of E. C. P. D. The assurances that I have from the Institute regarding the benefits to the engineering profession in Canada from the work of the Council are very gratifying, and the Council has profited by the presence of its new members.

A final important fact should be emphasized: With the American Engineering Council now defunct, E. C. P. D. is the only body which is in position, by reason of direct representation of professional, technical, educational, and legislative interests of the engineer's life, to deal effectively with the broad problem of professional development. It has already taken over from A. E. C., for instance, the functions of that Council's Committee on Professional Ethics. The member groups, however, will bear in mind the fact that E. C. P. D. is an advisory service organization, wholly responsive and responsible to its constituent bodies; and the Council must be cautious to confine itself to matters strictly within the scope of its charter and to avoid the danger of spreading itself too thin. But the fact remains that if coöperative progress is to be made by the engineering organizations, E. C. P. D. is now the only central medium through which that progress can be made.

II. Membership and Activities

A complete understanding of the Engineers' Council for Professional Development must include a knowledge of its constituency as well as the work in which it is engaged. Here emphasis should again be placed on the fact that the Council has functions of advice and recommendation only and does not administer any project unless it is definitely approved by a majority of the constituent groups.

The constituent bodies include the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, the National Council of State Boards of Engineering Examiners, and the Engineering Institute of Canada.

The work of the Council is indicated by the activities of five principal committees. Concerning these activities I append brief reports for which I am indebted to the respective committee chairmen.

1. *Student Selection and Guidance.*—Recognizing the importance of providing for interested young men information concerning the mental, physical, and personal requirements for a reasonable future in the engineering profession, the Committee on Student Selection and Guidance is organizing committees of engineers to meet with those high-school boys who have made inquiries concerning the study of engineering. Probably 8,000 boys attended such meetings last year. In carrying on this work the committee has received valuable support from the secretaries of the national engi-

neering societies holding membership in E. C. P. D. and from the local sections or committees of these societies. Local and state engineering societies have also aided. Moreover, the public schools, except in one city, have welcomed the help of engineers in giving information concerning the education and work of men in our profession. Gratifying reports have been received concerning the helpfulness to the high-school boy of such personal contact with a practicing engineer.

Linked with the problem of providing adequate guidance to prospective students is that of making possible the selection of better engineering talent. The committee is studying means of measuring more effectively scholastic proficiency and personal fitness for collegiate and professional training. In order that entrance into the study of engineering may be confined to those likely to succeed in it and that as a result withdrawals may be reduced, the committee is urging higher standards of admission to engineering schools.

To succeed the pamphlet "Engineering: A Career, A Culture," published by the Engineering Foundation in an edition which is now nearly exhausted, the committee has prepared for publication another entitled "Engineering as a Career." The usefulness to E. C. P. D. of such a publication on guidance is great.

2. *Engineering Schools.*—This committee, for the first time in the history of our profession, has appraised in an unbiased manner the programs of study of engineering schools, and has prevented a multiplicity of accrediting agencies in the field of engineering education by preparing a list of 542 undergraduate engineering curricula in 125 institutions. One hundred and sixty-four curricula were inspected but not accredited, and action on three curricula is pending. Though the major portion of the program was completed by October, 1939, the activity of the committee during the past year has included the re-appraisal of 70 curricula not previously accredited and the inspection of 32 curricula not on the accredited list of October, 1939.

The basis for accrediting has been a sound educational program, and inspecting committees were cautioned against undue standardization or forced regimentation of engineering education. Quantitative criteria were subordinated to qualitative factors as a measure of the soundness of a program of study.

The visits of inspection by E. C. P. D. committees since 1935 and the friendly advice given to engineering schools, when requested, have in these cases resulted in higher entrance requirements, better curricula, more adequate facilities in building and quipment, and improved as well as enlarged engineering teaching staffs.

An analysis of the data gathered by the Committee on Engineering Schools and a report thereon were made by Professor D. C. Jackson at the instance of the Committee with the financial support of the Carnegie Foundation for the Advancement of Teaching and published in the year 1939 as a pamphlet entitled "Present Status and Trends of Engineering Education in the United States." A copy was sent to the office of the president of each institution supporting an engineering school on the accredited list, to each dean of an engineering school on the accredited list, and to the libraries of such schools. Other copies were made available through the headquarters of E. C. P. D.

3. *Professional Training.*—Professional training is part of the continuing processes of education that are but barely begun in the engineering schools. In the first few years after graduation, the young engineer finds his most serious challenge. If he is to continue to advance in the profession, he must do more than acquire the technique and practices of his immediate job. His future will often depend as much on the knowledge and experience he gains through contacts with fellow engineers, through working with them to broaden his understanding of the engineer's position and responsibility in society.

To aid junior engineers in this critical phase of their development is the function of E. C. P. D.'s Committee on Professional Training. Working with the local sections of the constituent societies, it has encouraged the organization of many junior engineering groups throughout the country. Most of these have for their chief objective improvement in the professional status of their members through study courses, lectures and discussions, plant visits and inspection trips. Self-analysis questionnaires and suggested reading lists of both engineering and non-technical literature have been prepared by the E. C. P. D. committee for the use of these junior groups. In some communities the committee has cooperated with the engineering schools in organizing and publicizing their extension courses. And now that the National Defense Program has stimulated many companies to set up training courses within their own plants, the committee is finding a still greater opportunity to help young engineers take root and grow in the profession.

4. *Professional Recognition.*—Professional recognition is a normal goal following the attainment of an engineering diploma and professional training in the school of experience. This committee is concerned with "methods whereby those engineers who have met suitable standards may receive corresponding professional recognition." The principal agencies according recognition are engi-

neering societies (independent and autonomous, and differing in their requirements for membership) and state engineering registration boards, operating under different laws in seven-eighths of the states. E. C. P. D. has set up as a "suitable standard" certain minimum qualifications for an engineer—including education and capability developed in practice—which are generally accepted and afford a basis for common requirements for society membership and legal registration.

Professional recognition—the goal of education and experience—implies entrance into the engineering *profession*, and the young engineer should understand just what his profession is and what are its privileges, opportunities, and responsibilities. But just what is it? It is not a single organization or a unified group. Its development has come principally through many societies devoted primarily to technical advance in their respective fields. This development, while fruitful in technical progress, has not promoted professional solidarity. It is true that recently legal registration by the states has created a new grouping on the basis of competency, but though the 70,000 registered engineers about equal the total membership of the older societies, a majority of each group does not belong to the other.

In its recent annual report the committee urges that our societies make "a study of the Engineering Profession including its present status and development" and seriously consider whether their "profession can adequately meet its obligations and opportunities as an aggregation of individual groups, loosely linked by numerous common agencies." It also urges that our societies encourage their student groups to become "interested in a study of Engineering as a Profession, including its present status and its development; also the field of professional ethics." The ideas and ideals implanted annually in 10,000 engineering graduates leading them to distinguish engineering as a profession from engineering as a technical occupation, may give the coming generation a better profession than we have known.

The committee is planning to take up directly with the proper officers of the several societies the carrying out of the general projects above mentioned.

Summarizing, the general objective of the committee is to develop a proper understanding of what constitutes the professional status of the engineer as a basis for professional recognition and to help engineering students to an appreciation of professional attitudes and conduct.

5. *Principles of Professional Ethics.*—This committee was originally sponsored by the American Engineering Council, and upon

the discontinuance of that body the sponsorship was taken over by the E. C. P. D., additional members having been appointed in order to provide representation for all the constituent Societies of the E. C. P. D.

Prior to this change in organization, the committee had undertaken a study of existing codes of ethics in the engineering field and had considered the advisability of a universally accepted single code and the form which such a code should take.

Though progress has been slow, as is natural where communication must be carried on mostly by correspondence, there is now being formulated a preliminary draft of a report on a code of ethics for guidance in the engineering profession. This report will contain (1) a preamble briefly stating the origin and the need in intimate life of canons of ethics, (2) a statement of underlying principles, (3) a statement of reasons for excluding from the present code business rules of practice, and (4) a specific code for ethical conduct.

The object of this study is to bring to the attention of prospective and practicing engineers an ethical code, generally adopted, which may stimulate the minds of students and the younger engineers toward ethical thinking and may supply to mature engineers information regarding what their Societies expect of their professional conduct.

If such a report, when completed, is approved and recommended by the E. C. P. D., the committee feels that the governing boards of the constituent Societies may come to adopt it as their individual and collective expression concerning the field of ethics and that it may gradually be adopted by the local engineering societies, with the result of a very definite contribution to the solidarity of the engineering profession.

* * * * * *

The foregoing brief review of the composition, opportunities, and current activities of the E. C. P. D. indicates something of the Council's fitness and of its officers' plans for putting into effect the objectives of its charter, as well as something of the progress which it has already made. Looking ahead, the Council is, I think, justified in the hope that with the active interest and adequate support of the constituent bodies it may serve engineers increasingly in the cause of professional development.

Respectfully submitted,

ROBERT E. DOHERTY,
Chairman

ANTIPHONAL RESPONSES

By GILBERT E. DOAN

Head, Dept. of Metallurgical Engineering, Lehigh University

There is much airing of opinions about engineering education, its superb cultural values and its glaring defects. Each of us takes his turn at expressing himself. The rest listen and wait their turns. Regardless of what is said, nobody replies to much of it, nobody disagrees with it in print, and certainly nobody does anything much to put the views into practice.

A dozen of the most eminent engineers in American industry may take a unanimous position as to what is needed in engineering education.* A dozen leaders in the education of engineers may take an identical position as in the recent committee report on "Aims and Scope." † It makes little difference to us in the rank and file. When a new department head is appointed, he builds himself a new curriculum without any reference to this unified body of opinion. If his departure is pointed out, he merely says, "I know better than all those men," and carries out his plan. This is one of the aspects of democracy. But a system permitting such liberties will continue to work only if each one in authority strives to view *all* of the evidence bearing on a question without prejudice, and then makes his final decisions in full recognition of all the facts. We are not doing it today in engineering education.

When general views are aired, it is the duty of each of us to point out their limitations and defects. Thus we may finally agree on certain fundamentals of engineering education, or at least be able to understand where the principal schools of thought differ, and what limitations there are to each viewpoint.

I have had my turn at airing my views in the JOURNAL. Nobody paid much attention to them. Now I am going to criticize the views of Dean Derleth and President Sieg in the October JOURNAL in the way I wish someone had taken my thesis to pieces.

Upon examining Dean Derleth's paper, I find that the evidence flatly contradicts what he says on page 97. When he says that representatives of industry praise breadth and then demand specializa-

* G. E. Doan, JOUR. ENG. EDUC., Vol. XXVII, No. 9, May, 1937, pp. 680–685; F. L. Eidmann, JOUR. ENG. EDUC., Oct., 1937, pp. 116–118; R. E. Doherty, JOUR. ENG. EDUC., Sept., 1934, p. 26; Wickenden Report, Vol. I, p. 71, 1930.

† JOUR. ENG. EDUC., Mar., 1940, p. 555.

tion, I say the facts flatly contradict him. These facts are marshalled in the above references. Our leading engineers in the steel industry, the top engineers in the motor industry, the chemical industry, the electrical industry, and the air conditioning industry, as outlined in the above papers, say industry is *not* looking for specialists in a narrow field of engineering upon graduation. They are looking for well-grounded, alert boys with as much initiative as possible. As far as the evidence is available to me, what Dean Derleth says just isn't so. And we as a Society ought to *know* which view is correct. Our committee on "Aims and Scope" also says it isn't so. So does the Wickenden report. This monumental survey conducted by this Society in 1923–29 reports on curriculum on page 71 as follows: "In so controversial a field, it is an advantage to begin with some point of agreement. *The verdict of all parties consulted, teachers, graduates, engineers, and industrialists, is definitely against specialized training for undergraduates.*"

The "Aims and Scope" report concludes: "Some of the advanced technical subject matter now included in undergraduate curricula should be transferred to the postgraduate period where it may be pursued with a rigor consistent with preparation for engineering specialization."

These are the facts. The job can be done in four years if we "prune to the essentials," and it should be done in four.

There may be much wrong with arts education, as the Dean quotes Bacon and Hogben to prove. I don't know. Arts education isn't our business. But if our leading engineers aren't wrong and if the committe of leaders in engineering education named above aren't entirely wrong and if the Wickenden report isn't wrong, then there are changes badly needed in our present system for educating engineers. If, however, these three groups are wrong, we ought to know it at once. That *is* our business.

President Sieg says he too desires to have engineers more socially conscious. "But it is in the manner of accomplishing our ends that perhaps I differ from those who would cure the fault by the old methods." It is important to notice this point because this speaker takes some mean flings at the humanistic and social studies which would lead a casual reader to believe that he totally despises them.

In the final analysis, however, Mr. Sieg thinks that he might favor inserting short courses on economics, sociology, city planning, etc., but he says, "I would be inclined to have adult and expert engineers direct these courses." Presumably he means engineers who know some economics and sociology, but he specifies only that they be adult and expert. We won't disagree much about their

being over 21 years of age, but an "expert" engineer might mean a man who knew all about electric arc welding and not much about anything else. This is rather a flimsy prescription, certainly, for learning something about economics and sociology.

At this stage he clinches his point as follows: Since many engineers rise to executive positions without much knowledge of social and economic problems, that proves that engineers don't need any more social and economic studies than they have been given at college in the past. Mr. Sieg apparently does not know that the leading engineers about whom he is talking, steadfastly advocate greater breadth in the education of future engineers. Apparently he is unaware too that *no social studies whatever* are included in the typical engineering curriculum today, except economics.

But Mr. Sieg has a panacea. It is "Public Relations," how to get along with human beings, how best to present one's ideas of a new bridge or dam. We curriculum builders should give consideration to including something about human relations and about how to win friends and influence people in our curricula, he advises us.

In brief, Mr. Sieg desires that engineers be more socially conscious and more adept at human relations, but he has no faith in the present courses in literature and sociology to develop these traits. A new course in "public relations" is, he thinks, the answer. This is the panacea. Just as if such a course wouldn't boil down to sociology and to the study of great episodes and great characters in literature as soon as you thought about it for one minute. Apparently President Sieg has had unsatisfactory experiences with the teachers of literature and the social sciences. Wouldn't the teachers of "public relations" be of much the same caliber? (After all, are the engineering teachers as a group definitely superior to those in the social sciences, or is the proportion of genius and deficiency about the same for both groups?)

There are many examples of Mr. Sieg's own consummate skill in handling people in this paper. For instance: How reassuring it is for a president to tell us engineers that "there was a day when . . . there was not enough culture in your curriculum," or again how flattering to hear "The engineer wrests from nature more than man can assimilate." And in derision he mimics our critics, "One should not simply build a bridge; he should check up on the social and economic value of the bridge." Finally, what ego-inflation when we hear that the teaching of sociology should be taken charge of by us engineers; arts students should be compelled to take some engineering courses; and finally the engineering method should be used in teaching social studies, this

latter in spite of the clear admission on Mr. Sieg's part that the engineering method deals with things while the social studies deal with persons, the two being completely different.

Mr. Sieg certainly pats us on the back and we appreciate the gesture. But if we are engineers, we are out to improve our results and we don't want to be rendered complacent by too much backslapping. Neither are we as engineers willing to tolerate much loose talking about our principal problems.

Dean C. M. McConn, of Washington Square College in New York City, says he hears much airing of views on engineering education but very little "antiphonal response." Let's have more response from readers until we have run some of these ideas into their holes and tagged them "right" or "wrong."

ENROLMENT–STAFF RATIOS

By GEORGE C. ERNST

Assistant Professor of Civil Engineering, University of Maryland

Critical studies of teaching loads for staff members have been made by the Society [1] and by several institutions.[2, 3, 4, 5] These studies leave little to be said with regard to the details which must be worked out in order to assure an equitable distribution of an existing institutional load. A major weakness of our present methods, however, is stated by Professor Stewart [4] with regard to the determination of the maximum size of section. It is pointed out that a criterion for determining the maximum size of section is lacking and that "the figure . . . should be established by those who are experienced in the teaching of that subject. Where room space and equipment are limited, they, rather than the size for effective teaching, may be the determining factor. . . ." A five year study (1935 to 1939, incl.) of the curriculums, staffs, and enrolments of 110 leading engineering schools has led the writer to conclude that, in many cases, little serious attention has been given to this important matter. At present the traditions, precedents, and administrative leadership of the individual institutions are the essential factors in maintaining adequate teaching standards in the engineering schools. Due no doubt, to a lack of the proper amount and proportion of these essentials, an alarming number (although a minority) of the 110 schools apparently accept or encourage increases in enrolment without making adequate provision in the teaching facilities prior to the anticipated increase. The precedent of harmfully large sections in combination with heavy teaching loads is established rapidly under such conditions. Effective teaching as well as the professional development of the school

[1] "Report of the Investigation of Engineering Education," 1923–1929.

[2] "A Study of the Division of Faculty Time in a Department of Electrical Engineering," L. S. Foltz, *Proc. S. P. E. E.*, Vol. 36, 1928, p. 533.

[3] "Report of Teaching Load Survey of the Engineering Division, Iowa State College," M. P. Cleghorn, *Proc. S. P. E. E.*, Vol. 37, 1929, p. 857.

[4] "Teaching Loads—Their Measurement and Calculation," L. O. Stewart, *Proc. S. P. E. E.*, Vol. 42, 1934, p. 225.

[5] "Evaluation of Faculty Loads in Institutions of Higher Learning," A. S. Knowles and W. C. White, *Proc. S. P. E. E.*, Vol. 46, 1938, p. 798.

and staff member is hampered and becomes virtually non-existent after a few years under such a regime.

If a load of 15 classroom hours per week per staff member [1] is considered desirable, a sufficiently accurate estimate of the proper number of teaching staff members (or of the total enrolment which can be accommodated by a given institution) for a desired type of teaching is not difficult to make, providing that a criterion is established for the ratio of enrolment to staff (the average number of students per staff member). Such a value should not be interpreted as the number of students per class or section, but rather as an average value sufficiently liberal to permit development of the school and staff as well as the proper instruction of students. The size of sections and the individual teaching loads, of course, should be distributed in accordance with the aims of the college and the aptitudes of the various staff members. The aggregate development of the college, however, is seriously hindered if there is insufficient flexibility in the adjustment of teaching load.

A study of the opinions expressed in the JOURNAL and *Proceedings* of this Society seem to indicate that the majority feel that engineering education should be as it is at present, a compromise between that offered by the liberal arts colleges and that offered by the strictly professional schools. If present teaching conditions, on the average, are felt to be satisfactory, then the proper criterion for the average number of students per staff member could be determined best from the data collected during the E. C. P. D. inspections which show a value of about 18.

The writer has come to the personal conclusion that the limits should lie between 15 and 20 students per full time engineering staff member devoting his time to teaching. An average of 21.4 for the year 1938–1939 was obtained from the study of the 110 engineering schools previously mentioned. The same study also yielded the following average number of classroom hours in engineering subjects per week for each student,

Freshman	9
Sophomore	12
Junior	24
Senior	30

These values will be used, in subsequent discussion of the problem, as typical of engineering schools in general, although it is recognized that actual average values should be determined for any specific school.

The distribution of enrolment stated in the 1923–1929 Report was as follows,

Freshmen	37.3%
Sophomores	26.2
Juniors	19.7
Seniors	15.8
Special	1.0
	100.0

The approximate distribution shown below will be assumed for convenience, inasmuch as percentages consistent with a specific school should be obtained from the records of that school and would require revision each year,

Freshmen	38%
Sophomores	26
Juniors	20
Seniors	16
	100

The total institutional teaching load in terms of student classroom hours per week per 100 students enrolled may be calculated as below,

$$(38)\ (\ 9) = 342$$
$$(26)\ (12) = 312$$
$$(20)\ (24) = 480$$
$$(16)\ (30) = 480$$
$$\text{Total} = 1614$$

For a school having an enrolment of 500 students (approximately the average for the United States), the load would be about $1614(5) = 8070$ student classroom hours per week to be taken care of by the teaching staff in addition to their other recognized duties.

The number of teachers required for the load of 8070 student classroom hours per week is computed below on the basis of the suggested limits of 15 classroom hours per week per teacher and an average of 15 to 20 students per teacher,

For 15 students per teacher, $8070/(15)\ (15) = 36$ teachers.
For 20 students per teacher, $8070/(15)\ (20) = 27$ teachers.

The study of 110 schools showed teaching staffs from 10 to almost 60 members for this size institution in 1938–1939, with the scatter rather uniformly spaced. This spread appears to exist almost irrespective of the magnitude of the enrolment considered[6] and is difficult to justify in spite of the variations in teaching methods and engineering content of the curriculums.

[6] "Professional Standards vs. Mass Production in Engineering Schools," *Civil Engineering*, September, 1939.

In order to evaluate the teaching capacity of an existing or contemplated staff in terms of the total enrolment, it is necessary to reverse the above described process, which may be illustrated more conveniently by the equation given below,

$$N_t L_t = N_1 L_1 + N_2 L_2 + N_3 L_3 + N_4 L_4$$

in which, N = number of individuals, the subscripts t, 1, 2, 3, 4 denoting teachers, freshmen, sophomores, juniors, and seniors respectively.

L = average classroom load per week per individual, with subscripts as above. For teachers this must be interpreted as average student classroom hours per week per teacher.

For any specific case, N_1 (the number of entering freshmen) would carry the burden of adjustment if, as previously suggested, the value for the average number of students per full time engineering teacher (contained as a factor in L_t) is rationally determined for the desired quality of instruction, perhaps from the data obtained by the E. C. P. D. inspections. L_1, L_2, L_3, and L_4 should be weighted averages obtained from the various curriculums by using the proportion of the total enrolment to go to each department, which would be indicated adequately by past records. The determination of N_2, N_3, and N_4 involves a certain amount of care and judgment due to the irregular students, but can be made with the requisite accuracy in any case. The sum of N_1, N_2, N_3, and N_4 would be the total enrolment.

In conclusion, serious consideration could be given to the stabilization of enrolment-staff ratios (the average number of students per engineering teacher) as a progressive move toward the further improvement of engineering education. The expansion or growth of an institution under such an arrangement would be limited only by the ability and willingness of an administration to supply adequate teaching facilities simultaneously with the anticipated increase in enrolment.

Such stabilization might be attained under the present 4-year curriculum, a 5 or 6 year curriculum or a pre-engineering term, but the necessary basic requirement is a determination to improve engineering education by some means in addition to the academic manipulation of subject matter.

BUSINESS TRAINING FOR ENGINEERS

By H. B. COOLEY

Assistant Professor, Economics and Business Administration, West Virginia University

There has been much discussion over a period of years as to the subjects which should be included in an engineering curriculum. Comparisons have been made between the professions of law and medicine on the one hand, and that of engineering on the other, to show the need for an extension of the four-year engineering course to five or six years. The author agrees fully with those who feel that four years is an insufficient time in which to train the engineer in his profession and also supply a sufficient training in the various fields outside those of a strictly technical nature, which should be present for the development of a professional man. He feels, however, that the engineering course should remain a four-year course and that such additional training can, and should be, supplied by the student either before entering engineering school, by taking additional work while enrolled in the engineering school (with the necessary lengthening of his engineering course), by post-graduate study or by self-improvement by means of night school, extension courses or reading after he has completed his engineering course. Engineers and engineering faculties should do all in their power to encourage the young engineer to continue to broaden his knowledge.

Regardless of the merits of the arguments advanced in favor of the four-year, five-year or six-year engineering course or the merits of a Liberal Arts course followed by graduate work in engineering, the fact remains that the engineering course will remain a four-year course generally for a number of years to come. Accepting this, the question is what training should be offered in this four-year period? The engineering curricula are rather uniform throughout the country, a uniformity which has arisen through a recognition of basic engineering courses by the colleges, rather than through the action of some body or authority which imposes its will upon the schools as a group. When these basic courses and a few advanced, specialized courses in each field are disposed of there remains little time for so called "service" courses.

It seems to the author, however, that the engineering schools as a whole have paid little attention to a broad field of training and

one closely related to the work of the engineer—namely the field of "Business." It is true the time is limited but probably nothing could be more useful, nay, even more necessary to the engineer than a knowledge of business principles and practice. Where to obtain the time for such training would depend, of course, upon the individual curriculum considered, but that such training should be given is perfectly apparent when one considers the position of the engineer in society.

No matter what branch of engineering may be considered the young engineer finds himself a member of an organization engaged upon some productive work—the design or erection of structures, the operation or maintenance of a plant, the design of a new product or later becomes a consultant dealing with organizations engaged in such activities. How are they organized and how do they function? What are the lines of authority? What records are necessary and which ones constitute unnecessary waste? What are the general rules determining good or bad organization set-up and operation in a given case?

Unless the young engineer is to remain a "hewer of wood and a drawer of water" in his profession the time quickly comes when he is confronted with the necessity of a knowledge of business practices. He can learn them, of course—as many others have learned them—in the hard school of experience, or he can study them after he has completed his engineering work. The knowledge acquired by experience however, may be costly, and the necessity for self-training may not be discovered until after the need for the knowledge has arisen. The basic principles may be taught the engineering student in a comparatively brief course and the ground-work laid upon which to expand the knowledge in the future as the opportunity presents itself.

Such subjects as business organization, finance, statistics, accounting, marketing, purchasing, transportation and insurance are all of vital importance to the engineer. He is too often prone to think only in terms of production (either the creation of a capital good for use by an industrial concern, or a bridge, highway or tunnel for a public utility or political body, or the mass production of articles for sale to the consuming public, or in the maintenance of a structure or plant), and does not concern himself with activities of a related nature. Why is the particular structure erected or replaced at the present time? What are the sources of funds by which his work is financed? Who will benefit and who will suffer because of such activities? What are the principles and business practices which lie behind the actions and activities of the various organizations with which he comes in contact—including

his own? These are questions in which the young engineer should be, but in the great majority of cases is not, interested.

If the engineering student received such basic training his opportunities for initial employment and for later advancement would be considerably improved. The engineering training in itself is very valuable and many of the country's top business executives began their careers as engineers. Why should not the engineering schools recognize the close relation existing between the engineering training and the field of business? Why should the latter be surrendered to the Colleges of Commerce and Business Administration and the engineer limited to the technical field except in a few cases where ability or circumstances made possible a change from the technical to the business field?

The study of business principles has passed the infant stage and now embraces certain definite subjects just as the engineering curricula do. In cases of specialization there is much difference of opinion, of course, as to what should be included—but there is also this same difference of opinion in engineering. The basic business subjects are well recognized and may be divided into production, marketing, finance, statistics and accounting.

It would not be possible to cover adequately all these subjects without the addition of one or more years to the engineering curricula but the object would not be that of training the student in the field of business. The primary object would be to train an engineer, but an engineer who would have a knowledge of the other fields, who would understand them and be able to develop in them as the occasions arose. In accounting, for example, the purpose should not be to train the engineer as an accountant, or even as a bookkeeper or clerk, but should be to give him a knowledge of bookkeeping and accounting methods so that he would use, understand and appreciate the usual business records even though he is unable to keep them.

The difference in objectives between engineering school treatment of the business subjects and that of the College of Commerce would materially shorten the period of training required by the engineering student. Another saving in time would result if it were recognized that the engineering student possessed certain training which was not commonly found in business students. In statistics, for example, some time is consumed in teaching the student how to plot graphs, and to use logarithms and the slide rule. This is unnecessary in the case of the engineering student as this information is more fully presented in other courses. Again, the object would not be to teach the student to assemble and present statistical data but to be familiar with the use and interpretation of the data and the cautions to be considered in such interpretation and use.

As to the detail knowledge which should be presented there would, of course, be a considerable difference of opinion. Some would feel that the need would be covered by a course in theoretical economics, such as the basic economic course in a Liberal Arts College. Unless the course is presented exceptionally well the result is apt to be of little or no value to the engineering student. Much of the information presented, it is true, falls into one of the fields mentioned above but the approach is theoretical and the application of the theoretical principle is usually left to the student and is seldom, if ever, made. In other cases attempts have been made to narrow the subject to a particular phase of engineering. Such application is beneficial but the course should be regarded as a technical one and not one of a general nature and does not generally offer training of a broad nature which would prepare the engineer to take his place in an organization or to develop in the business phases of the organization's activities.

The author feels that there are certain business fundamentals which should be part of the training of the engineering student. This is based upon fourteen years' practical engineering experience in addition to business training and experience. Much of his business information has been acquired through practical experience —an embarrassing and, at times, costly procedure. Much of this could undoubtedly have been avoided had the fundamental business principles been taught in his engineering courses. A general outline of this basic information may be briefly stated.

The engineering student should have a knowledge of the various forms of business organizations, the types of internal organization and the advantages and disadvantages of each. In the field of finance he need not be familiar with the workings of our banking system, or the control of the financial system by the government, but he certainly should know the difference between stocks and bonds, the various classes of each, the advantages and disadvantages of each class and the rights possessed by the holders of such securities. He should be familiar with notes and recognize the basic principles governing short-term and long-term financing. The interest rates, and the purchase and sale of securities at a discount or at a premium and the probable result of such transactions upon the business issuing the security, and the investor, should be understood.

As has been mentioned above, a knowledge of accounting is not desired for the purpose of making an accountant of the engineer. He should have a sufficient knowledge of double entry bookkeeping to understand the use of the records and the principles of debit and credit, without the practice on detailed bookkeeping records to enable him to keep such records. He should

understand the balance sheet and profit and loss statements and the relation existing between the various items in the two statements, the method of computing and recording depreciation and the method of recording the acquisition, disposal or loss of an asset. The formulation of a budget for future operations and the principles governing the distribution of costs should also be understood. In addition to the actual knowledge of accounting the engineering student would also acquire some skill in the presentation of figures which could be carried over to the engineering reports.

The methods of collecting and presenting statistical data, the sources, uses and the cautions to be observed in such collection and presentation should be made familiar to him. He should know and be able to use the various, common statistical measures, and be familiar with index numbers and the statistical series in general use.

In marketing, the buying motives and methods of marketing and distributing goods, the factors determining price and the elements of transportation costs should be considered. He should be familiar with the usual business insurance policies and the types of risks most commonly covered.

The above enumeration may sound rather formidable but it must be remembered that only basic principles are covered and constitute a minimum of business training which should be the property of the engineer upon graduation. The knowledge in any one field may be expanded later and the details supplied, but the engineer thus trained should never lose sight of the other fields or the relationship existing between them.

Such a survey course in business, in the author's opinion, is more beneficial than more extended training in any one field—such as accounting—without any training in the other business subjects. The knowledge so gained will be of more use to the engineer (and the author speaks from the practical experience of himself as well as other engineers with whom he has been thrown in contact) than the highly specialized training in one narrow field. If time permits, and the specialized training is desired, this can be superimposed upon the survey course with little loss of time, as the survey course would cover comparatively little of the particular field to be developed.

The course outlined above could be taught in a single semester—three hour course and some basic economic subjects which had not been covered from a practical viewpoint in the business survey course could be covered in a second semester course. Such subjects as foreign trade, supply and demand, marginal utility, public finance, taxation, and labor policies and legislation could be developed.

Who should teach such a course—when and if offered? Inasmuch as the various subjects, if developed, constitute fields in themselves, it is improbable that many instructors will be found to develop each field to its fullest extent—even in such a survey course. It seems to the author that the course would be more effectively presented by an engineer provided, of course, that the engineer understood the basic principles of the various subjects involved. He is more familiar with the engineering student and his viewpoint, and should be able to present the subjects more effectively even though he may not be as familiar with the subjects as some non-engineering instructor would be.

Summary.—The engineering and business fields are closely related but the engineering schools generally fail to recognize the advantages of training in business and permit this opportunity to go by default to Colleges of Business Administration. Much of the engineer's work deals with organization and administrative duties and a knowledge of business principles and practices is very desirable—if not absolutely essential.

Considering the limited time available in the four-year engineering course the question is one of deciding the best use of the time available for so-called "service" courses. A survey course in Business covering the basic principles of business organization, finance, accounting, statistics, marketing, insurance and transportation could be presented in a three hour, one semester course. This would furnish a minimum of knowledge along these lines, without which the engineer is at a decided handicap in his work. It would also furnish the ground-work for future development—either in other courses or in actual practice as the occasion arose. In view of the author's experience as a practicing engineer it is difficult to imagine a better use to be made of the limited time required for such a course.

SUGGESTIONS FOR IMPROVING ENGINEERING TEXT BOOKS IN WHICH COÖRDINATES ARE USED

By E. A. HERTZLER
Pratt Institute

Failure of students to get the full significance of certain fundamental relationships in analytic geometry leads in students' later work to difficulties in trying to set up differential equations and other relationships in engineering problems. This paper suggests ways for improving text books used by students in engineering including texts in analytic geometry, calculus, differential equations, and all texts and hand books in engineering where coördinates are used.

A specific instance of a faulty statement in analytic geometry is in the definition of abscissa and of ordinate of a point in a plane using rectangular coördinates. Some texts define abscissa as the distance "between" the y-axis and the point (x, y), and define ordinate as the distance "between" the x-axis and the point (x, y). Neither of these definitions is quite correct.

The correct definition of abscissa and of ordinate is the following: Abscissa is the distance *from* the y-axis *to* the point (x, y), measured parallel to the x-axis. Ordinate is the distance *from* the x-axis *to* the point (x, y) measured parallel to the y-axis.

Certain other texts word the definitions correctly, and illustrate with figures which are incorrect. Figures 1, 2 and 3 show how abscissa and ordinate are illustrated in some texts. Each of these figures fails to show correctly the true nature of abscissa or of ordinate.

The true nature of abscissa and of ordinate is shown graphically in Figs. 4 and 5.

As a specific illustration of cases in which students have difficulty with more advanced problems, because the true nature of coördinates has not been understood, the following problem in work is quoted from a well known text. "Find the work done in pumping out a hemispherical vat having a diameter of 6 feet and filled with water, if the water is discharged through a pipe 8 feet above the top of the vat."

We shall take the origin at the top of the vat in the center, as shown in Fig. 6 and Fig. 7, with the standard $+$ and $-$ directions along the coördinate axes.

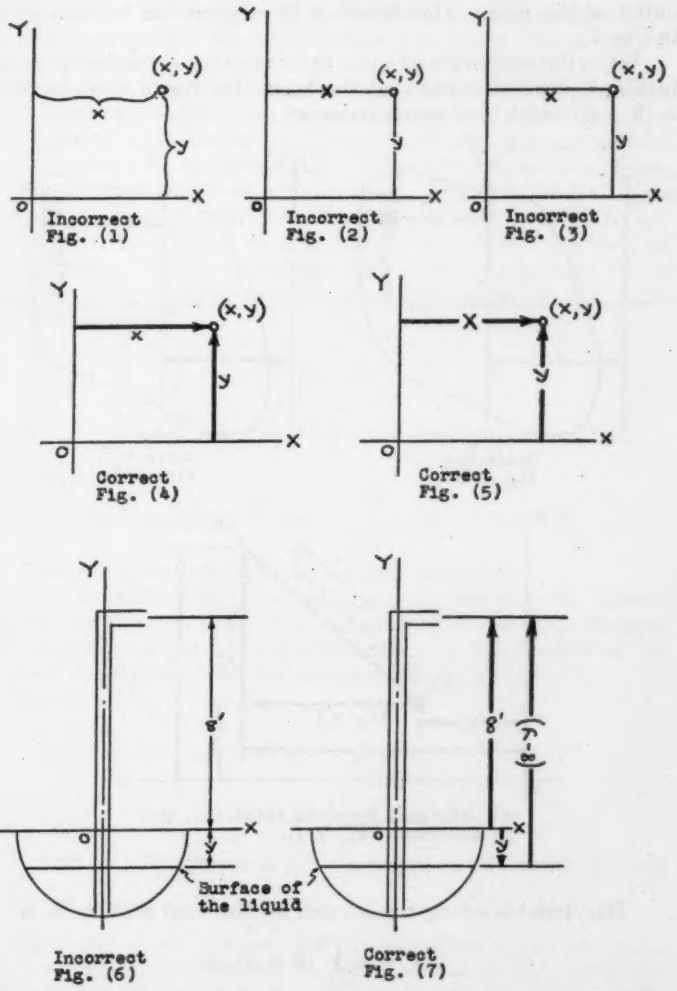
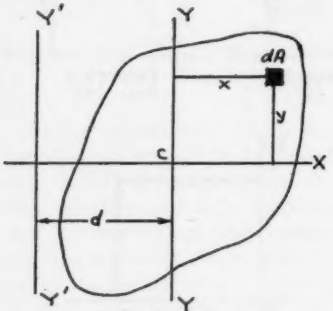


Figure 6 shows the conventional but incorrect way to set up the problem, and Fig. 7 shows the correct way to represent the coordinates in the problem.

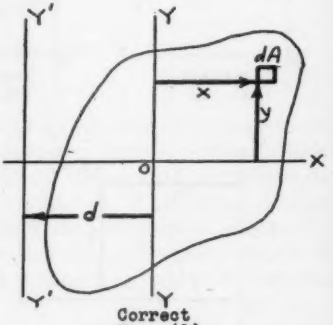
The height through which an element of volume of the liquid must be lifted is the distance *from* the surface of the liquid *to* the

outlet of the pipe. This height is $(8 - y)$ as can be seen easily in Fig. 7.

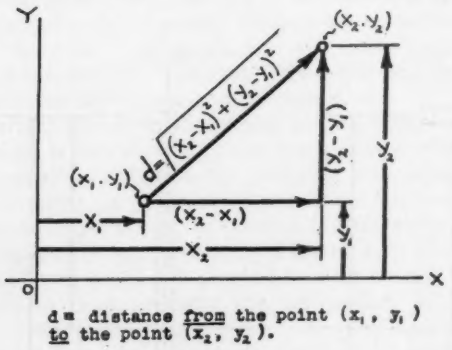
When the problem is set up in the conventional manner as shown in Fig. 6, students write that the height the liquid must be lifted is $(8 + y)$ which is of course incorrect.



Incorrect
Fig. 218



Correct
Fig. (8)



d = distance from the point (x_1, y_1) to the point (x_2, y_2).

Fig. (9)

The students set up the integral for the total work done as

$$W = w \int_0^v (8 + y) \cdot dv$$

[where $W \equiv$ total work, $w \equiv$ density of the liquid, $y \equiv$ ordinate, and $v \equiv$ volume]. This integral will not give the correct result. Using the same notation the correct integral is

$$W = w \int_0^v (8 - y) \cdot dv.$$

The students' failure to set up correctly so many of their problems in engineering is due to their lack of understanding of the true nature of coördinates.

Errors in the use of coördinates appear in articles, in handbooks, and in text books which add to the students' confusion. As a specific illustration of this last statement the following is quoted from a well known text in engineering. Here the authors were dealing with moment of inertia of a plane body. "In Fig. 218 let YY be any axis through the centroid, C, of an area and let $Y'Y'$ be any axis parallel to YY and at a distance d therefrom. Further, let the moment of inertia of the area with respect to the axis YY be denoted by $\bar{I}$ and the moment of inertia with respect to $Y'Y'$ by I. By definition then,

$$I = \int (x + d)^2 \cdot dA$$

$$= \int x^2 \cdot dA + 2d \int x \cdot dA + d^2 \int dA.$$

"Therefore

$$I = \bar{I} + A \cdot d^2 \qquad \text{since} \qquad \int x \cdot dA = A \cdot \bar{x} = 0.$$

"Hence the following proposition may be stated:

"The moment of inertia of an area with respect to any axis in the plane of the area is equal to the moment of inertia of the area with respect to a parallel centroidal axis plus the product of the area and the square of the distance between the two axes."

The equation

$$I = \int (x + d)^2 \cdot dA$$

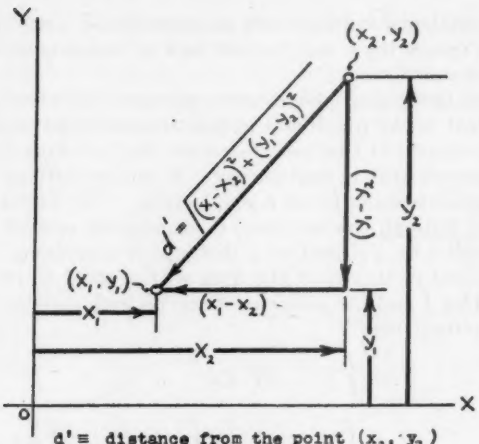
$$= \int x^2 \cdot dA + 2d \int x \cdot dA + d^2 \int dA$$

is not correct. *It happens to give the correct result because the term* $2d \int x \cdot dA$ *is zero.*

Figure 218 shows the way the figure appears in the text, and Fig. 8 shows the correct way to represent the facts. Using the authors' own statement of the conditions, the equation for the moment of inertia, I, should be

$$I = \int (x - d)^2 \cdot dA$$

$$= \int x^2 \cdot dA - 2d \int x \cdot dA + d^2 \int dA.$$



d' ≡ distance <u>from</u> the point (x_2, y_2) <u>to</u> the point (x_1, y_1).

Fig. (10)

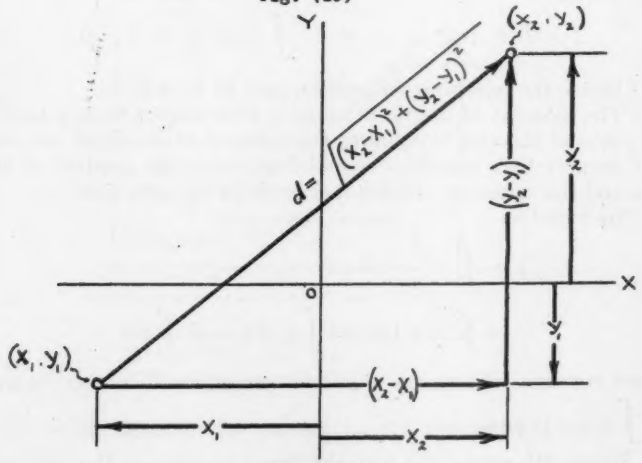


Fig. (11)

Therefore

$$I = \bar{I} + A \cdot d^2 \qquad \text{since} \qquad \int x \cdot dA = A \cdot \bar{x} = 0.$$

Also the authors' statement of the proposition should be as follows: The moment of inertia of an area with respect to any axis in the plane of the area is equal to the moment of inertia of the area

with respect to a parallel centroidal axis plus the product of the area and the square of the distance *from* the centroidal axis *to* the other axis.

The foregoing illustration is but one of many which could be given showing how coördinates are not used correctly in engineering literature.

Another specific instance in which text books in analytic geometry fail to prepare students for future work is the formula for the distance from one point to another.

1. $$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2},^*$$

which is illustrated in Fig. 9. Most texts in analytic geometry call this the formula for the distance "between" the points (x_1, y_1) and (x_2, y_2). Such a statement is not entirely correct.

The correct statement of this formula is that d is the distance *from* the point (x_1, y_1) *to* the point (x_2, y_2).

In a similar manner, as shown in Fig. 10,

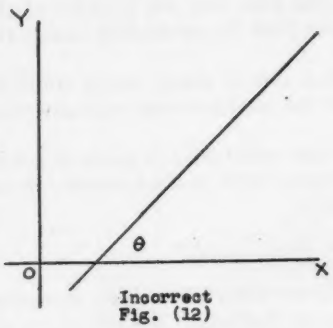
2. $$d' = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

is the formula for the distance *from* the point (x_2, y_2) *to* the point (x_1, y_1).

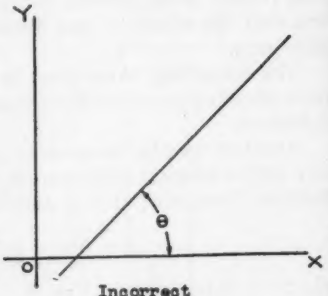
Text books would be improved also if they would show in the figures how a problem appears in more than one quadrant. Text books very carefully set up each problem in the first quadrant where it is possible for a student to follow the solution without having a real understanding of coördinates. Then when the student encounters problems in which he must use other quadrants, he is "lost" because he does not understand coördinates. Figure 11 shows how the true nature of coördinates can be made clearer to students by showing the use of the formula for the distance from one point to another when one of the two points is in the first quadrant and the other point is in the third quadrant. If figures were used which gave students a clear picture of the significance of coördinates, students would not have nearly so much trouble in setting up differential equations in engineering work.

Still another way in which text books fail is in the definition of angle of inclination. Angle of inclination is not defined correctly, and is not illustrated correctly in the figures, in many texts. The following quotation is taken from a text in analytic geometry. "The angle of inclination of a line is the angle which the line makes with the positive direction of the x-axis." Another definition in a

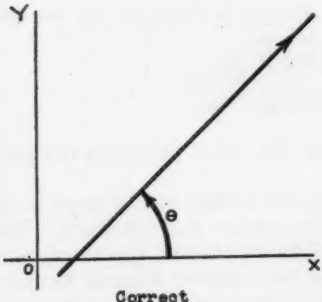
* Some persons may say that when a square root is taken the result may be plus or minus. That is not true if no $\pm$ signs appear before the radical. If no sign appears before the radical, the sign is understood to be $+$ only.



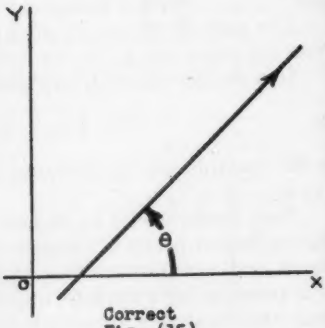
Incorrect
Fig. (12)



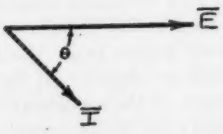
Incorrect
Fig. (13)



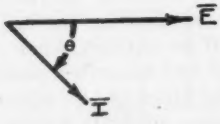
Correct
Fig. (14)



Correct
Fig. (15)



Incorrect
Fig. (16)



Correct
Fig. (17)

text book in analytic geometry is the following: "The inclination, θ, of a line L is the angle formed by the x-axis and the line L." Neither of these definitions is correct.

A better way to define angle of inclination is as follows: The angle of inclination of a line is the angle *from* the x-axis *to* the line, starting on the right side of the point where the line intersects the x-axis.

Figures 12 and 13 show how angle of inclination is often indicated. Both of these are not wholly correct. Figures 14 and 15 show the correct way to represent angle of inclination in a figure.

In a similar manner, the angle which is usually described as the angle "between" two straight lines should be described as the angle *from* one straight line *to* the other.

An illustration of the carry over of these incorrect expressions into engineering is the following: In electrical engineering, phase angle is defined as the angle "between" the voltage and the current. Phase angle should be defined as the angle *from* the voltage vector *to* the current vector.

Figure 16 shows the conventional way of illustrating phase angle, θ, and Fig. 17 shows the correct way of representing phase angle.

Intercepts are defined correctly in some text books, but there are some texts in current use in which intercepts are not defined correctly. The following definition is quoted from a well known text in analytic geometry. "The distances cut off by a curve on the axes are called its x- and y-intercepts." A better way of defining intercepts is the following: An x-intercept of a curve is the distance *from* the origin *to* a point where the curve intercepts the x-axis. A y-intercept of a curve is the distance *from* the origin *to* a point where the curve intercepts the y-axis.

The author wishes to emphasize by repetition what was said in the beginning that engineering students' lack of understanding of the true nature of these fundamental relationships is a definite handicap in engineering studies. The author thinks that the incorporation of these suggestions into engineering texts, and into the teaching of engineering subjects, would aid students (1) in setting up their engineering problems, (2) in the solution of their problems, (3) in the analysis of results and (4) in the general understanding of their problems in engineering.

M.K.S. UNITS IN ELECTRICAL ENGINEERING COURSES

By PAUL L. MORTON

Instructor in Electrical Engineering, University of California

The meter-kilogram-second (Giorgi) system of electrical units has, in the last five years, received such widespread recognition that general adoption by electrical engineers appears to be inevitable within the next decade. In spite of its advantages, however, many teachers of electrical engineering are not yet using it, and the lag is most noticeable in precisely that field where its advantages are greatest, namely elementary courses and courses given for non-electrical engineers. It is therefore appropriate to examine the reasons for delay.

Several reasons for hesitation are evident: First, teachers of electrical courses are familiar with the historical units and conversion factors, and therefore do not feel so keenly the difficulties met by students and others whose acquaintance with the equations of electricity is less thorough and prolonged. Second, teachers are often committed to published texts, and hesitate to make changes that might jeopardize books, reference material, tables, etc., that have proved satisfactory in the past. Third, and chiefly, confusion among writers about just what constitutes the m.k.s. system, and just what is implied by its adoption, has led many to think that it is hopelessly involved in controversy, or at best is in the class of the theoretically interesting but practically negligible qes (earth-quadrant, gram $\times 10^{-11}$, second) system of Maxwell.

Actually, no fewer than twelve of the units of the m.k.s. system are already familiar (meter, kilogram, second, joule, coulomb, ampere, volt, ohm, watt, henry, farad, and weber), and all but one of the eight electrical units are far more commonly used than the corresponding c.g.s. electromagnetic, c.g.s. electrostatic, or any other unit of the physical quantity concerned (the maxwell, or "line" of flux, is more widely used than the weber). Adoption of the m.k.s. system therefore means the adoption of units of magneto-motive force, reluctance, etc., consistent with the practical series of electrical units named above, thereby making the m.k.s. system complete and sufficient for all electrical derivations and problems, and permitting the abandonment of the c.g.s. electrostatic, c.g.s. electromagnetic, and any other systems now used in this work.

Since no change in the classical c.g.s. systems is proposed, nothing will prevent the use of the electrostatic, the electromagnetic, or the Gaussian mixed c.g.s. system in any study where these respective units may be more convenient; it will simply be unnecessary to use the classical systems in cases where they have always been a nuisance, tolerated because no alternative was available.

The only question, affecting the average user of the m.k.s. system, which is not yet settled and which the user must decide before adopting the system, is the question of rationalization. Rationalizing, in this instance, means adopting the ampere-turn, rather than a unit smaller by a factor of 4π, as the m.k.s. unit of magnetomotive force. This procedure automatically decreases the size of the unit of permeability and increases the size of the unit of permittivity by the same factor, compared with the unrationalized units. (However, tables of the permeabilities and permittivities of materials are not affected, because such tables give the ratios of these constants to those of free space and the numerical values assigned to the free-space constants are immaterial.) Rationalization eliminates the factor 4π which appears, in the c.g.s. systems, in problems showing rectangular symmetry (parallel-plate condenser). Solutions to spherical problems, rationalized, show the 4π explicitly, and cylindrical problems (magnetic field about a long straight conductor), show a 2π, as would appear reasonable from the formulæ for surface areas of spheres and cylinders respectively. Rationalization was first proposed by Oliver Heaviside as a correction to be applied to the c.g.s. systems, but although he attracted able advocates as well as opponents, the change was repeatedly rejected. With respect to the m.k.s. system, however, the argument of tradition and literature in the unrationalized system has little force; while the fact that the ampere-turn is and will continue to be a natural unit of mmf., regardless of the convention adopted, assumes decisive importance. The texts so far published which use m.k.s. units use the rationalized form,* and the only country (Japan) which has taken a definite stand has also recommended rationalization. It is therefore likely that the trend toward rationalization will continue and general agreement will soon result.

The more abstract question of what electrical quantity, if any, is to be associated with mass, length, and time, in the establishment of a system of dimensions associated with the electrical units, and the unrelated but often confused question of which units lend themselves most readily to the construction and maintenance of reliable standards, may well be left to specialists. As Birge † and

* Since this paper was written several texts using m.k.s. units have been published; at least one of them uses the unrationalized form.

† Birge, R. T., *Am. Physics Teacher*, Vol. 3, p. 171, 1935.

others have pointed out, the number of dimensions in a system and their choice is a matter of definition governed by convenience; in the study of relativity it is customary to express the dimensions of all quantities including mass and time in terms of the single dimension length, while an equally logical procedure might assign a separate dimension to every physical quantity considered. For convenience in analysis the choice of one electrical dimension seems desirable, and charge, resistance, permeability, and permittivity have been proposed. More simple dimensional formulæ would result from the choice of charge or resistance, but universal agreement is quite unnecessary.

As for standards, all units should logically be defined as multiples of, say, the mass of an electron or of a proton, the wavelength of a specified kind of light, the period of vibration of some specified atom, the charge of an electron, the velocity of light in free space, or other equally fundamental natural physical constants. In the case of length, at least, such a standard would be much more accurately permanent and reproduceable than the presently-accepted international prototype meter. The electrical standards historically maintained for comparison are standards of resistance and of e.m.f., but these are now calibrated in terms of the mechanical units by the use of current and inductance in a "current balance." As knowledge is accumulated calibration techniques will probably continue to change, but the present electrical units can nevertheless be used with confidence, with the number, kind, and construction of standards and the revision of the fifth significant figures of conversion factors left, as now, largely to the national standardizing laboratories.

There appears to be no reason, then, why the m.k.s. system should not be adopted immediately by any instructor so minded, irrespective even of the action of other instructors in the same school. Most written material can be read in the m.k.s. system by dropping the powers of 10 and inserting, wherever the relative permeability μ (or permittivity κ) appears, the absolute m.k.s. value $\mu\mu_0$ (or $\kappa\kappa_0$). In many texts the chapter now devoted to unit systems can be omitted entirely. Experience at several schools has shown that students welcome the change, even when the m.k.s. system is not used exclusively. In fact the students collectively will probably display considerably less inertia than their instructors.

Appendix

For comparison, a few familiar equations are shown in the rationalized m.k.s. form (column I) and in the c.g.s. form after converting to practical units (column II). By definition $\mu_0 = 4\pi$

$\times 10^{-7}$ henrys per meter; $\kappa_0 = 10^7/4\pi c^2 = 8.854 \times 10^{-12}$ farads per meter; and $c = 2.998 \times 10^8$ meters per second.

Equation	I M.k.s. Form	II C.g.s. Form
Induced voltage	$e = -N\frac{d\phi}{dt}$ volts	$e = -N\frac{d\phi}{dt}10^{-8}$ volts
Magnetic flux	$\phi = Ni\frac{\mu\mu_0 A}{l}$ webers	$\phi = \frac{4\pi Ni}{10}\frac{\mu A}{l}$ maxwells
Force on a conductor	$F = Bil\sin\theta$ newtons	$F = \frac{Bil\sin\theta}{10}$ dynes
Capacitance:		
Parallel-plate capacitor	$C = \frac{\kappa\kappa_0 A}{d}$ farads	$C = \frac{\kappa A 10^9}{4\pi c^2 d}$ farads
Concentric-sphere capacitor	$C = 4\pi\kappa\kappa_0\frac{r_2 r_1}{r_2 - r_1}$ farads	$C = \frac{\kappa 10^9}{c^2}\frac{r_2 r_1}{r_2 - r_1}$ farads
Two parallel cylinders ($r \ll d$)	$C = \frac{\pi\kappa_0}{\log_e (d/r)}$ farads per meter	$C = \frac{1}{60c\log_e (d/r)}$ farads per cm.
Magnetic field intensity:		
Distant r from a conducting filament	$H = \frac{i}{2\pi r}$ ampere-turns per meter	$H = \frac{2i}{10r}$ gilberts per cm.
Distant x along the axis from the center of a conducting loop	$H = \frac{r^2 i}{2(r^2+x^2)^{3/2}}$ amp-turns per meter	$H = \frac{2\pi r^2 i}{10(r^2+x^2)^{3/2}}$ gilberts per cm.
Self-inductance of two parallel cylinders ($r \ll d$)	$L = \frac{\mu_0}{\pi}\log_e (d/r)$ henrys per meter	$L = \frac{4}{10^9}\log_e (d/r)$ henrys per cm.

FILMS AND SLIDES AS AIDS IN THEORY COURSES *

By W. R. BRYANS

College of Engineering, New York University

The use of projected pictures for educational purposes goes back many years. Many of us remember the travel lectures of the "Gay Nineties" with slides projected by the old steropticon, whose source of light was an oxygen-hydrogen torch playing on a lime pencil and from which originated the expression "being in the lime-light." This projector was later succeeded by the open arc with its sputtering carbons, and some of these are still in use. Around the time of the World War motion pictures began to assume importance in certain educational programs, stimulated, no doubt, by attempts to combine entertainment and education for soldiers. The great stimulus to the use of motion pictures in education, as Mr. Tomlinson † points out, was the introduction in 1923 of the 16-mm. non-inflammable film with simplified camera and projection equipment. A few years later, non-inflammable 35-mm. film was adapted to still projection in place of lantern slides and also for use in special library viewing machines, such as the Recordak, Argus microfilm reader, etc. These rolls of films known as microfilms or bibliofilms are now in common use in libraries, especially as a means of conserving rare books, and in banks, engineering offices, and other places where permanent records in space-saving form are needed.

In recent years, a vast amount of material has been produced in the form of educational and reference movie films, and more recently a large number of educational stills in the form of 35-mm. film rolls. One University alone stocks over twelve hundred 16-mm. movie films which are lent to schools and organizations. These have titles ranging from "Einstein's Relativity Explained" to "Getting Rid of Rats." The General Electric Company supplies films such as, "The Zephyr," "Conquest of the Cascades," etc., and the U. S. Bureau of Mines supplies many films dealing with the metal-working and petroleum industries. Erpi Consultants and Eastman have produced many good educational films covering a wide range of subject matter on the high school and junior college levels. Such commercially-supplied motion-picture films and microfilms have

* At S. P. E. E. Convention, Berkeley, California, June, 1940.

† "The Use of Motion Pictures in Engineering Education," Geo. P. Tomlinson, *S. P. E. E. Journal*, May, 1939, p. 739.

been widely used in high schools and elementary schools. Their use in engineering colleges has been mostly in orientation courses and in meetings of student branches of engineering societies. However, there is much use of motion pictures for research work in engineering colleges, for example: slow-motion pictures in time and motion study and ultra high-speed motion pictures for the study of machine-motions, combustion processes, and aerodynamics. Baron Shiba's and Edgerton's work are well-known examples of the ultra high speed type of motion picture photography.

Close examination of catalogue listings of films and microfilms supplied by such agencies as have been mentioned reveals that much of the available material consists of what may be called "process films," that is, films which visualize processes of manufacture or construction rather than theory. Those that attempt to visualize theory are mostly on the high-school level or in a few instances, on the freshman level. *The use in engineering colleges of "process films" is usually a waste of time except in orientation or purely descriptive courses. Such films are ordinarily of no use to the teacher whose problem is to help a student visualize some fundamental concept or abstract principle.*

Those of us who teach theory courses such as mechanics, thermodynamics, and electricity would certainly feel lost if our classes were transferred to a room in which there was no chalk and blackboard. It would certainly take many words to explain ideas that are readily conveyed by sketches. We depend on graphic presentation more than we realize. There are, in all theory courses, uses for blackboard and crayon for which there is no practical worthwhile substitute. On the other hand, there are many occasions when a properly equipped room would permit the projection of two or three minutes of pictures or diagrams during the course of the hour, thereby adding greatly to the interest and understanding. In our department of Engineering Mechanics at New York University, our interest in movies for theory courses grew out of a series of slides that Professor Charles E. Gus prepared for a course in Machine Kinematics. These slides dealt with velocity and acceleration diagrams and vectors, and proved very useful. Probably most of us have sketched one phase of some similar diagram on the blackboard and wished that we could sketch fast enough to show all phases through a complete cycle. Hence, with these slides it was a logical step to give them animation and this has been done with results that you can judge when you see them on the screen. Here it is pertinent to repeat a comment made by Professor Dana last year in connection with Mr. Tomlinson's paper: "The first thing to determine is whether or not motion is necessary in the study

under discussion." We should be careful to avoid letting our enthusiasm take us into movies where pictures or stills, or mathematical analysis could be used to better advantage. Motion pictures in such courses as physics, dynamics, fluid mechanics, thermodynamics, aerodynamics, direct and alternating current machinery, and machine design should satisfy Professor Dana's criterion. Possibilities also exist in other fields ordinarily thought of as static, such as photo elasticity.

In the course of his experiments with animated cartoons, Professor Gus, in coöperation with our Duplicating Department, developed a technique that materially reduces the physical labor of making a multiplicity of drawings. This technique consists of making one master drawing which contains all the phases of the complete cycle that are to be photographed. This original drawing is duplicated by the photo-offset process in very pale blue color, and as many copies are printed as may be necessary. A second original drawing is prepared, which shows all parts of the machine or picture that do not change from phase to phase. These parts would correspond to the scenery in a Mickie Mouse cartoon. This second drawing is photographed and over-printed in black on the photo-offset copies of the first drawing. The cost of these double prints is surprisingly low, being around $6 for 400 copies printed on 91-lb. cardboard. All that then remains to be done before photographing these prints with the movie camera is to draw each phase of the motion in India ink on the individual prints. The prints are then placed one at a time in a simple jig and photographed on the film roll. A camera must be used that is capable of exposing a single frame at a time. We have used both a Cine Kodak Special and also a Bell and Howell 141–B with equally satisfactory results.

At the Penn State meeting in 1939, in connection with the discussion at the Instructional Methods Division Luncheon, Professor H. J. Gilkey of Iowa State commented on the "difficulties inherent in motion pictures, such as interrupting the complete story for a discussion of different points." This particular difficulty has been overcome for us by Professor Granath of our Physics Department who has rebuilt for our use several 16-mm. projectors in which a window of Jena glass B.G. 21 is permanently mounted behind the film. This glass absorbs and radiates the heat and does not cut the illumination appreciably. With a 300-watt bulb in the projector, any one frame of the movie may be held on the screen indefinitely without danger of burning. A remote control-box with cable permits the speaker to start, stop on any frame, or reverse the film, from any position in the room without moving the projector. Some commercial projectors permit of single-frame pro-

jection, but do so through the use of screens which cut illumination 80 per cent or more.

Our experimental work with movies for theory courses has been along two lines:

1. Short animated diagrammatic cartoons. A few examples of these are as follows:
   (*a*) Counter-balance of a locomotive drive wheel.
   (*b*) Development of an involute gear tooth.
   (*c*) Quick-return mechanism; effect of changing center of rotation of oscillating arm.
   (*d*) Quick-return mechanism; velocity and acceleration vectors.
   (*e*) Aeronautics; conventional angles for yaw, pitch and roll.
2. This type can best be explained by a concrete example.

   In certain of our structures courses, a brief introduction is given to the subject of photo-elasticity. It would be very useful in such a course to take each student into the laboratory and go through a complete photo-elastic experiment. This is impracticable because of limitations of both time and space. The next best thing, therefore, is to bring the experiment to the classroom through the medium of motion pictures. We have made such a film consisting of 100 feet in black and white, and around 200 feet in color. Its objective is the visualization of basic principles. We are also working on a film for use in the first sessions of a mechanics of materials course. This combines animated cartoons with actual pictures of a tension test in a testing machine. Its objective is a visualization of stress-strain relations in elastic materials.

In the field of still projection we have been experimenting with some new uses of 35-mm. film. Original material is easily reproduced in this medium, either in black and white or in color. When in a hurry, we produce our own slides or rolls with a $20 candid camera and an inexpensive copying fixture at a cost of about four cents a frame. Commercially produced in sizable quantities, the microfilms cost around two cents a frame. One of our experiments may be of interest. For example, for our Evening Division classes in mechanics, we are preparing solutions to all assigned problems on rolls of 35-mm. film. Individual rolls of from 18 to 36 problems are placed in the library after assignments are due, and the student can study them at his leisure in the Recordak. In the Evening Division it is often difficult for students to find the time to consult instructors even though scheduled conference hours are provided.

Consequently, a student who has difficulty with a particular problem is apt to bring up the matter in class. This is satisfactory if several students have difficulty with the same problem but excessive use of class-room time for individual difficulties can be avoided by referring the individuals to the Recordak slides.

Another idea we have been experimenting with is the use of 35-mm. film stills in connection with ivory-color nucite chalkboard (glass blackboard). We have found that this material is translucent enough so that outline drawings of problems or machines on film can be projected through the nucite from the rear. Vectors or other supplementary matter can then be drawn on the nucite and subsequently erased if desired while discussing the problem or machine. Much time can be saved and a far better basic drawing produced. Projection can also be made from the front if the nucite is permanently attached to the wall, but shadows are slightly bothersome.

We are also planning to follow up some of the suggestions made in R. B. Ketchum's article on "Uses of Microfilms in Engineering Education" published in the December, 1938 issue of the JOURNAL OF ENGINEERING EDUCATION. In this article Dean Ketchum proposed that each graduate should take with him from college some twenty rolls of microfilm with around fifty exposures per roll. "The graduate would thus take with him a library of selected material of some thousand drawings, problems, tables, and diagrams for a total expense of about $20. If this material is carefully selected by the teachers and kept up to date, it will be more valuable than the student's notes and textbooks." Most young men these days possess a 35-mm. still projector for use with their candid camera and a library of this kind would not need much storage space. Dean Ketchum also makes some other suggestions as to possible use of microfilms and his short article is well worth reading.

The kind of movie film or 35-mm. still that is really useful in engineering theory courses is not available commercially for two reasons:

1. The market is too small and restricted to make their production a profitable venture.
2. The average professional producer cannot divorce himself from the idea of providing entertainment. He must have a continuity, and a scenario, and his objective is art, not logic.

It is for these reasons that the really useful projection material in theory courses will have to be thought out, staged, and produced by the engineering teacher. We can call on the professional for

the actual photography but even here it may be better to use a proficient amateur who knows what it is all about.

Probably one deterrent to the use of projection material in engineering courses lies in a traditional habit of thought. The idea of motion pictures or even slides connotes in the average instructor's mind the bother of setting up a screen, obtaining a projector and someone to run it, assigning the class to special room equipped with dark shades, and possibly the loss of one hour of valuable class time. If projected pictures, either movies or stills, are to be useful supplements to teaching, we should have more classrooms equipped with dark shades, permanently placed projectors, and permanent screens. The permanent screens may well be "nucite," which answers the dual purpose of screen and superior substitute for blackboard. In such a room short three to five-minute films or eight to ten slides can be exceedingly useful and do not ruin a discussion hour. Further, under such conditions the preliminary work would consist merely of bringing the slides or films to the room.

Films and slides are being used to an increasing degree in medical schools and in instruction in the pure sciences. Most of the material used is home-produced by the users. In engineering possibly more of this has been produced than most of us realize. The variety of material that I have been attempting to describe bears this out. At this Convention there are being exhibited at various times films on electrical theory by Woodruff of M. I. T. and Langsdorf of Washington University; on "Mechanics of Vibration" by Ryan of Minnesota, and on machine kinematics and photo-elasticity by Gus and others of New York University; also stereoscopic projection of descriptive geometry problems by Prof. J. T. Rule of M. I. T. Sometime ago the writer suggested to Dean Langsdorf that an interchange of such material between colleges would be desirable. I quote from his reply, "You are perfectly right in believing that an interchange of material between institutions is desirable. I shall be very glad to have copies of my little film available to anyone who is interested." We at New York University would be glad to loan our films or have copies made at cost for other engineering colleges. Incidentally, copies of 16-mm. film cost $3.75 a hundred feet in black and white and about $9 a hundred feet in kodakrome. Perhaps the sub-committee on visual education may perform a useful service in listing and arranging for the exchange of available material in this special field until the time when some foundation promotes a study of the possibilities and subsidizes large-scale production.

Appendix A

S. P. E. E. Papers on Use of Motion Pictures

Visual aids in the form of motion pictures have received very little attention from contributors to S. P. E. E. publications. The first *Proceedings* to carry an article on motion pictures was the issue of 1919. In this, Collins P. Bliss, then professor of mechanical engineering at New York University, described a plan for filming all the basic and essential industries of the United States. This was to be sponsored by a group known as the Visual Industrial Course, Inc., among the directors of which were Charles M. Schwab, Charles P. Steinmetz, and other notables of that day. The objective was a service to colleges and schools whereby "the methods, processes, and products of twenty-five to thirty basic and essential industries can be brought into the classroom by motion-picture slides and industrial manuals." Their first project was for an orientation film on General Engineering Practice. The Visual Industrial Course, Inc., apparently did not materialize as a going concern.

In an article in the 1928 *Proceedings,* page 834, Professor Francis H. Roys of Worcester Polytechnic suggests that the S. P. E. E. with the founder societies "collect and edit films to educate students in choice of career, what the various branches of engineering include, etc. and what the function of the trained personnel is."

In the 1931 *Proceedings,* Professor Miller of Rice Institute describes the better results obtained in teaching a section of descriptive geometry using animated cartoons as compared with a section in which the films were not used.

At the 1938 Texas meeting, George E. Tomlinson, senior engineer, T. V. A., presented a paper on "The Use of Motion Pictures in Engineering Education." This was printed in the May, 1939 issue of the JOURNAL on page 739. Mr. Tomlinson also gave a paper of the same title and exhibited a film at the Penn State College meeting in 1939.

Appendix B

The following have been suggested by an electrical engineering instructor as subject matter for short films on electrical engineering theory.

1. In the case of the generation of voltage by means of a d.c. generator the increasing effect of armature reaction with load would be well suited to this purpose. I can visualize that the addition of compensating windings, and then of interpoles could quickly force

the student to grasp the idea of the entire subject in a relatively short time.

2. I have frequently wished for an animated cartoon of armature coils, before, during, and after commutation. This would be of material assistance in showing current densities at the toe and heel of the brushes as well as the effects of voltages induced in these coils during the commutation period.

3. The induction motor rotating field and its associated vector diagrams. An animated cartoon of this type would show the instantaneous currents of the various phases and the consequent production of the revolving flux.

4. Fresnel's conception of oppositely rotating vectors, could well be applied to fluxes as he applied it to polarized light. This would aid materially in the understanding of some of the starting characteristics of single-phase induction motors.

5. In the case of synchronous motors the effect of power factor would lend itself to this type of explanation. The operation of synchronous motors in stable and unstable regions could also be adapted to this purpose.

6. Animated cartoons of the effect of space charges within vacuum tubes lends itself to this treatment as do other topics of electronics.

7. The effects of suddenly applied loads on synchronous machines, their transient conditions; the variation of impedance of synchronous machines and other phenomena lend themselves to this treatment.

CORRELATION OF COURSES IN MECHANICS*

By J. C. OTHUS

Associate Professor of Mechanical Engineering, Oregon State College

The subject as assigned, "Correlation of Courses in Mechanics," would seem to imply, according to the dictionary, the placing of mechanics courses in relationship with something else. This element not being specified in the assignment, we shall view our courses in mechanics in several relationships.

Correlation With Related Subjects

The courses most directly related to Mechanics themselves are Mechanics courses, which Alfred P. Poorman lists in the first paragraph of his extensively adopted text book, "Applied Mechanics." He says "Mechanics, in general, is that branch of physical science which treats of the effects of forces upon the motion or upon the condition of material bodies. It (mechanics) includes Physics, Celestial Mechanics, Applied Mechanics, Strength of Materials, Hydraulics, and Mechanics of Gases." Others could be added.

The correlation of these subjects would present an interesting problem but rather than consider them, let us consider the relationship which applied mechanics bears to the other technical courses in an engineering curriculum. These curricula are today so well established in our American engineering colleges that none would differ greatly from those which we prescribe at Oregon State College.

The group of civil engineering courses listed in our catalogue which includes mechanics and those for which mechanics is a prerequisite numbers eleven courses with a total of thirty-nine term credit hours. If to these are added the courses in engineering problems, the sequence would total fourteen courses, with a total of forty-five term credit hours. It is recognized that the civil engineer applies the principles of mechanics in all of his structural designs, and that mechanics is the foundation of the civil engineer's training.

An examination of the mechanical engineering curriculum shows an even more extensive list of courses which come in this mechanics

* Presented at the 48th Annual Meeting, S. P. E. E. (Mechanics), Berkeley, Calif., June 24–28, 1940.

sequence. Here the total, including engineering problems, is sixty-one term credit hours listed under twenty-two separate course numbers. This may seem a large number for mechanical engineering, but in addition to the usual strength of materials and machine design, the list includes courses required in the aeronautical engineering option which is essentially a course in structures.

On the other hand, the same catalogue reveals that the electrical engineers have little concern with structures, and are so occupied with the study of electricity that they take but two courses, statics and dynamics, beyond the engineering problems courses which is common to all three branches.

It is the correlation or relationship of these allied subjects which we might here consider. Such a long list of courses must of necessity be administered in several groups, with separate instructors for each group. These instructors are too often unaware of the relationship of the training they are giving to that which the student will get in another group. The staff in engineering problems, for example, may be conscious of the bearing their work has on mechanics which is to follow in the sophomore year, but they too often fail to realize that the foundation they are laying is to support the structure which includes such subjects as stress analysis and machine design. The more significant failure to recognize this relationship, however, rests more generally with the instructors of the advanced courses. The teacher of machine design, for example, should bring to bear upon the student the pressure of all of the training he has experienced in preparation for that work.

Application of a "System" in Mechanics

Starting with engineering problems in the freshman year, one of the chief benefits to be derived by the student should be supervised training in sheet composition. Student work in all classes at Oregon State College showed a marked improvement in neatness and orderliness with the establishment of the course in engineering problems. It is insisted in this course that the student develop a system whereby his work will not only be intelligible to others, but he himself will be able to follow the work through after the ink is dry. If he shows a sketch (and he is encouraged to do this) he is required to *use* that sketch by relating his solution to it, using letters on his figure to which he refers in his solution of the problem. Advantage of this training should be taken by the group of instructors who teach mechanics in the sophomore year. The insistence on following out this system will yield large dividends in the form of more thorough mastery of the subject.

In the application of this system to the solving of mechanics problems every teacher and student knows that the greatest difficulty is the drawing of the figure, which in this case is the free body diagram. What to select for a free body too often seems to be a mystery, but if the student is urged to select some part which is acted upon by the force which he is required to find, and not too many other unknowns, a little practice will enable him to make a good selection. Then the instructor should insist upon a vector representing every influence which is brought to bear upon that body. In other words, it must be a complete free body diagram, with no forces omitted. With each known vector designated by its value on the sketch and each unknown bearing a letter, the student should have no difficulty in deciding which equation might be written containing only the one unknown required. The designation of this equation by the conventional sigma sign must be insisted upon, for it not only serves the instructor as an aid in checking or grading the problem, but more important, its use will be a great help to the student in writing the equation. If the student is impressed with the meaning of the sigma, and if he systematically includes the consideration of *every force,* pointing to each one in turn on the free body diagram with his finger as he places its value in the equation, the chances of his making an error are greatly reduced.

The University of Washington enjoys an enviable reputation for high quality of work in the field of applied mechanics and the success of its graduates, working in this field. At the recent Pacific Northwest meeting of the S. P. E. E., Professor Alfred L. Miller presented a paper in which he told of the system established thirty years ago at that institution by Professor C. C. More. Listed among the characteristics of the courses are the "Minimum standards of form and workmanship which are established and firmly enforced." Specifications for workmanship in a typical course were given and included the following:

Engineering computations must be clear, neat and accurate. In order to develop these characteristics in your work, the following specifications will be enforced.

Clearness

1. *Materials and Equipment* as specified.
2. *Pages* properly headed, numbered and in order.
3. *Index* parts of problems in right-hand margin and draw lines across the pages between the parts.
4. *Size of Numerals* not less than 0.2 inch high except exponents, subscripts and numerators and denominators of simple fractions may be proportionately smaller.

5. *Size of Sketches* in proportion to the size of numerals and adequate to clearly show dimensions and other data.
6. *Fraction Lines* horizontal.
7. *Point off* numbers of more than four places in thousands and thousandths.
8. *Answers* clearly marked and indexed including units.

Neatness

9. *Pencil Lines* sharp, black, and not easily smudged.
10. *Erasures and Corrections* neatly made. Pages clean.
11. *Shape of Numerals* approximating the Reinhardt standard.
12. *Clearance* between all lines and numerals must be obvious.

Accuracy

13. *No Scratch Work or Scratch Paper.*
14. *No Short-Cutting;* one step at a time; in substituting in an equation, do so item by item in order. Cancellation is permitted if clearly recorded.
15. *Decimal Points* clearly made. Numbers less than unity must include a zero to the left of the decimal point.
16. *Individual Work* representing your own thought and effort without assistance or hindrance from others.

In discussing More's system later, another University of Washington professor, from another department of the Engineering College, expressed the opinion that the More system had been carried to such an extreme that it had become a fault. This professor stated that a student trained under this system would be unable to find the maximum moment in a simple beam without going through the ritual required of him during his training. He did admit, however, that his own students taking service courses in the Civil Engineering Department under Professor Miller did learn their mechanics thoroughly and we must admit that if the system accomplished this, it is justified.

As a teacher of both machine design and mechanics, the writer is told by his machine design students that he is the most insistent of all their instructors on good form in written problem work. While this is some satisfaction, the results obtained in many cases are quite discouraging, and coöperation on the part of the entire staff in demanding work conforming to this system would be greatly appreciated.

Let us look for a moment at the administration of mechanics courses. Professor R. T. Challender of Montana State College quotes the following information gotten from responses to "a ques-

tionnaire sent to a large and representative group of colleges and universities having well established engineering departments." In answer to the question as to what department was responsible for the Mechanics courses, the replies tabulate as follows:

Civil Engineering	43%
Mechanical Engineering	14%
Mechanics Department	37%
General Engineering	6%

With such a distribution it is obvious that many major departments are sending their students to other departments for mechanics as service courses. The subsequent courses in the mechanics sequence are then given within the major department. This break in continuity has even a greater tendency to introduce a lack of correlation of method, than in cases where the advanced courses are given by a different group of instructors but in the same department. It would seem that the solution of the problem of setting up a standard of workmanship might be made a problem of the entire engineering college, to be administered by the Dean.

Mechanics in Engineering Education

The position of mechanics in the engineering curriculum makes it distinctive and important for until the sophomore year the student's training has been diversified and of a preliminary nature. Mechanics comes at the junction of this path with his subsequent technical training and professional practice. It should serve as the transition from his training in physical science and mathematics to the technical field. In this position mechanics can serve to eliminate the student who is unfitted to proceed in engineering due to lack of ability or preparation.

The teaching of mechanics affords the instructor an opportunity to give training in the use of the threefold languages used by engineers. The use of the spoken and written word has received the most attention, but still deserves more, judging by the average engineer's ability to use this our language effectively. The responsibility of giving training in the spoken and written word rests on the teachers of all technical courses, including mechanics.

Mathematics, while considered by the mathematician as a pure science, is used by the engineer as a form of language with which he expresses quantitative expressions and evaluations. A full appreciation of mathematics is vital to a successful engineering career, and it is also necessary for success in the study of mechanics and other technical courses. It is so important that a student attempting mechanics without the prescribed mathematical training is

handicapped at the very start, and may find himself among those eliminated from engineering training even though he has the native ability and interest required for success.

The third language, orthographics, while used extensively by engineers for purposes of record, is too often neglected as an aid to visualization and computation. Training in the use of this language can be afforded the student in his mechanics and other technical courses.

Since mechanics serves as a prerequisite for such a large number of subsequent technical courses, the responsibility for an orderly transition into the technical field and a correct foundation in fundamentals rests more heavily on teachers of mechanics than on any other single group of the entire engineering staff. If these requirements are properly fulfilled, and the training in subsequent courses is properly correlated with them, a pattern for performance will be formed which will contribute materially to the success of the student in his professional life after graduation.

ECONOMICS IN MECHANICAL ENGINEERING*

By ANDREW I. PETERSON

Assistant Professor of Engineering Economics, New York University

As a mechanical engineer, attracted in recent years by economics and mathematical statistics, I ask your indulgence in a few observations upon engineering economics. It is a subject overridden by social and cultural concepts, in confusion with objective approaches to specified technical tasks. Some engineers visualize it vaguely as a flood of confident generality from our more abstract social economists. An anecdote has been attributed to the dean of an eastern college of engineering who, under pressure, viewed a specific contribution by one of his faculty as being brilliantly conceived but of no practical value to anyone. There are some of us who envy the immaculate celibacy of pure and abstract science, forgetting sometimes that in applied science we are expected to provide a very material world with offspring than can economically make their own way. There are others who worship an opposite extreme of simple erudition in current business techniques and philosophies.

In a ten year study of post-graduate employment at the Sibley School of Mechanical Engineering at Cornell, research, design and development work claimed up to twenty-one per cent of the graduates in their first four years, but fell off to some seventeen per cent in the fifth. Industrial production work rose consistently to eleven per cent, costs and appraisals to about eight per cent and sales to some twenty per cent. In the now classic Investigation of Engineering Education by our Society, the technical group declined to about twenty-one per cent for the older graduates. Perhaps we can grant that there is a limit to pure technical specialization in engineering practice.

But from the viewpoint of strictly professional engineering, I am among the first to raise the query as to how far it is possible or desirable to go beyond the narrow concept of technology which has dominated our curricula of the past. Receiving universal support for some time has been economics, a term popularized to cover every interest from theoretical economics to the administrative arts. As a rhetorical question: should we train business men with a back-

* Presented at the 48th Annual Meeting, S. P. E. E. (Engineering Economy), Berkeley, Calif., June 24–28, 1940.

ground of engineering fundamentals, or applied scientists with sufficient breadth in quantitative economics to more usefully apply their technical knowledge? I lean to the latter, not only because engineering is an applied science, but also because I believe that it is inefficient without professional competence in economics.

Our general political economist defines his subject as a science dealing with human wants and the satisfaction of those wants; in other words, with production, distribution and consumption. It now has many dimensions: market price behavior, distribution of income, money and banking, competition and monopoly, insurance, social security, national planning, international economic policy and countless other phases of importance to our social evolution. But we have a confusion of fact and fancy, striking changes in economic philosophy, and popular movements for large-scale intervention by government. We appear to be entering an era of political economics in the literal sense.

The engineer is vitally interested, of course, in the effects of social change upon his work, and feels some responsibility for the social incidence of his invention. But it is his primary job, *as an engineer,* to provide economically the technological means to the ends specified by society and enterprise, without first weighing the social desirability of those ends. Of course, as citizen or entrepreneur, he must critically interpret and shape the general development. His focal interest, therefore, would seem to enter by way of the specific task, tracing the related variables through successive environments to the general economy as a whole.

If our evidence is valid, we find the engineer's post-graduate development evolving from technical design or research, through technical supervision of operations, to business administration. There are, of course, defections all along the line to purely commercial pursuits. All three however require the objective solution of economic problems. May I, therefore, attempt a classification of such problems in their order of importance and natural development in *technical* practice:

1. The selection, replacement and apportionment of the elements of design and operation; as Engineering Economy.
2. The quantitative resolution of economic characteristics in technical enterprises and operations, and the progressive redesign of their operating economies; as Engineering Economics.
3. The analysis of the economic growth and performance of specific industries and public works; as both Engineering Economics and Political Economy.
4. The interpretation of economic behavior and trends in the parent economy supporting these activities; as Political Economy alone.

As we reach the more advanced levels of interest, we are obviously concerned with the complex and less determinate problems of general social economy. Here the engineer needs broad graduate study in general economics, cultural experience, and a thorough grasp of a host of business techniques. Can these arts be taught or must they be acquired? How far into the future is it possible or desirable to go with our training of the engineer, *as an engineer?* Is not our immediate criterion the extent to which the application of scientific method is possible?

In the engineering economy of isolated problems we generally seek the minimum-cost point of a series of discrete alternatives or of a continuous sum-function of cost variables that have a common independent variable of design, such as pressure, output or quality. We accept the time-value of money principle, making our choice on a basis of annual equivalent costs, present-worth, or the rates of return on increment levels of investment. We strive to approach overall economic reality more closely than is possible with the reckoning of current costs and profits by the arbitrary conventions of accounting. This is particularly true in problems of replacement economy, where we stress the recognition of net realizable values as the sacrifices of continued investment in existing alternatives, not the irrelevant book values presented by accounting records. Anticipating a challenge on this point, I might note parenthetically that any discrepancy between realizable and book values is properly chargeable to surplus, since past profits are partly derived through the arbitrary use of straight-line depreciation, where the rate is usually less than the true loss of value in the earlier years of life.

There are many powerful and critical analyses in technical engineering that grow out of these elementary procedures. They are not mastered, however, by the acquisition of a few techniques to be casually sprayed over our lecture notes in the usual technical course. There should be, if you permit, a specialized flow of instruction that only begins with the elementary analyses referred to. We are sufficiently familiar, I think, with the work of Professor E. L. Grant to use it as an excellent example of what we can do with engineering economy.

The next step is a more advanced technical rationalization of whole enterprises which are aggregates of unit operations. They may be power plants, power systems, pipe lines, manufacturing plants or merely large commercial buildings. In design, they have the same problems of choice and degree, although with greater complexity and interaction. In operation, there must be the resolution of quantitative operating characteristics and the constant redesign of the factors of production. Here we have possibilities that con-

cern the applied science of the engineer precisely; in fact, an aspect of economics that often can be developed by him alone. I hasten to add that I refer to quantitative technical studies and not the "blinding glimpse(s) of the obvious" that are occasionally produced in commercial management.

There are two principle variables relating our isolated technical problems to the enterprises containing them: the going rate of return and the economic lives of specific alternatives as they bear the impact of general technological development. In most cases, these are sufficiently stable to permit accuracy in *choosing* between alternatives. The long time rate of return, however, is a complex variable. It is a function of the dynamic evolution of market price and the engineering economics of operation. We thus introduce the broader aspects of general economics. Since the engineer is required, to an increasing degree, to analyze objectively the development of natural resources, technological products and public works, it appears that he must have a thorough understanding of some of the more rational phases of general economics. Individual enterprises must be keenly aware of their competitive positions as to product and the forces shaping their growth. Specific industries are more and more making a common problem of their positions in the economy. The chemical, machine-tool and power industries can well certify to the highly technical phases of competition and change.

In mechanical engineering, aside from the fundamental design of machine elements, we ordinarily think of power production and utilization as our primary interest. It is reported that our prime-movers in the United States exceed a total of 1,230,000,000 horsepower, of which 79 per cent is in automotive engines and 11 per cent in other transportation uses. For our steam plants, we like to dwell upon our improvements in thermal efficiency approaching approximately a level of 10,000 B.t.u. per kw.-h., and with binary cycles perhaps a level of 9200 B.t.u. per kw.-h. But are these justified as yet by the overall economy when other pertinent cost factors are considered? Our fixed charges may run from one-third of the total costs with a 100 per cent load factor, to three-quarters with approximately a 20 per cent load factor. Load variability, system development, fixed charges and plant operating characteristics are powerfully important factors in ultimate economy. The economic integration of unit operations is a problem that must be handled competently by the successful engineer.

L. W. W. Morrow, with others, has given us glimpses of the actual economic performance of large central stations. For sixteen of them, built between 1927 and 1935, he found that size was not a controlling factor in the low cost of power; that on the con-

trary, building "at the load" with completed stations was more economical than the development of centralized units, partly due to the migration of load centers and rapid changes in the art. Engineers appeared to over-design for fuel economy or other isolated elements, in many cases, increasing their investments, maintenance, repairs, payroll, and supervision to more than offset the anticipated gains. It now appears that lower costs must come from reductions in investment per unit of capacity, simplicity of design, standardization of units, more critical studies of load variability, load distribution, and ingenuity in meeting system peaks. If a technical moral may be drawn from such cross-sectional studies, it would be that engineers must look to more elaborate economic analyses of plants and systems as a whole.

The economic problems of design are numerous, but can perhaps be grouped into three categories: those affecting location; those affecting the economic size and number of standard operating units; those affecting the thermal efficiencies; and finally those determining the operating position of the plants in the systems as a whole. When we face actual operation and supervision, there is equal diversity in proper analysis. Changes in the cost of supply factors of production or in the character of the load variability should obviously produce prompt readjustments in operating procedures. We have made outstanding strides in the last decade in the theory and practice of load division between units within stations, and between the various plants within a system. We have had to extend remarkably our engineering analyses of the origins of costs in distribution to various types of consumer loads. Modern practice demands objectively obtained evidence in support of engineering recommendations and decisions.

When considering the smaller private plants, the same order of economic reality and competence is required. There are many that can be made to pay handsome dividends, despite the availability of public service, due to such factors as: remote location, low load factor, by-product possibilities of exhaust steam and the increment-cost character of generating facilities when other services must be provided regardless.

As a simple illustration of the engineering significance of a sound approach, I can quickly outline an actual case in a large city. An educational institution was faced with the replacement of an obsolete steam plant, public steam service being not available. The electric load factor was quite low. Since the turbine and Diesel electric investments were an increment upon the steam plant, as were the charges for labor and energy absorption from steam exhausted to the heating system, the plant competed very easily against local rates. With an annual output of some 650,000 kw.-h.,

it now produces a net saving of 12,000 dollars annually against the lowest available rate, with all capital charges accounted for.

The question has since been put as to the owner's position should the public service rates be drastically reduced, perhaps even to the present unit cost of 17 mills per kw.-h. This raises an important concept in replacement analysis. The recoverable or net realizable value of the abandoned electric plant would obviously be a small fraction of its going value or book value, and this is the significant investment that could be either recovered or continued by owner's choice. Likewise, the operating costs saved by such action would be the small increment previously referred to. All told, the continuation costs per kw.-h., *in such comparison,* would still be far below any purchase rate that could be offered. This is a very interesting point for plant owners to contemplate when they are being urged to abandon plants in which there are appreciable sunk-cost factors.

In the case of hydro-electric power, public opinion conceives of falling water as a free gift of nature, regardless of development and transmission costs. The subject is surrounded by misconceptions and fallacies, even in the minds of otherwise well informed people. Such plants are generally characterized by high and wide ranges of investments and very small variable-cost elements with load. The output of a specific project is limited to the potential value of the stream flow which, in turn, may not be available at the same time as the maximum demands of the system. Pondage provisions modify such limitations, of course, but often with serious investment costs. The dominant costs are fixed. As to transmission, we are familiar with the fact that at all but the higher load factors, it is cheaper to transport coal than electricity over the longer distances. Since the operating efficiency of the hydro-plant is almost as high as it can go, the engineer's problem in areas having ideal power sites is one of minimizing investment charges, and in other areas one of integrating its possibilities with steam plant operation for the maximum economy of the system as a whole. The analytical problems therewith are worthy of the best engineering economists we can produce.

The progress of the Diesel engine is familiar to us all. As our most efficient converter of energy, it retains its efficiency even in small unit capacities. For power plant work, its widest adoption has been in areas having cheap fuel oil, adverse coal and water conditions, and the necessity for transmission to widely scattered loads. In recent years it has been widely adopted for municipal power and pumping plants, and urban commercial buildings. Many of these situations profit greatly from the simplicity and efficiency of the engine, despite the relatively high investments per

unit of capacity that would otherwise tend to offset the production advantages. Unfortunately there are many cases of either misrepresentation or economic incompetence. We hear of high speed equipment for heavy duty service, insufficient reserve capacity, poor speed and voltage regulation, excessive maintenance, unreliability, and other factors that return some building owners to the public services with unfair prejudice. Here again there is a real need for engineering economists who can realistically analyze technical cost variables and competently rationalize our economic professional experiences. The cry of public utilities that some of these cases are unfair competition is probably justified.

But it is not my purpose to compare the merits of various sources of power; rather to stress the problems of design and integration. It is obvious that fixed charges are relatively dominant over fuel and other operating efficiencies, and that the competent utilization of various types of capacity with respect to specific characteristics of load is the engineering-economic problem of today. But above all, it should be noted that in many cases our problem is one of economic degree or level rather than the open-and-shut acceptance or rejection of any specific technological factor.

Historically, perhaps our next outstanding concern is with the manufacture of basic materials, machinery and durable consumers goods. But whether it be with the direct design and development of such goods or with their efficient utilization in the production of other goods, we are faced with technical and economic problems of performance as never before. Mass production, which we view as the American road to Utopia, has many obvious advantages but also many specific limitations. Enormous outlays are required in durable, specialized machinery which must risk the storms of demand change and process obsolescence. Complex organizations of unit operations cannot tolerate failure in any of the individual links. The load factor of output is critically important in the price absorption of high levels of fixed charges or overhead.

The design of operations and products is the job of mechanical engineering economics. It must conserve investment, reduce operating costs and minimize working capital. The overall cost function in variation with volume must be borne in mind when choosing between methods of production. There must be stream-lined flows of materials and processes, and structural designs to fit. There must be careful consideration of the economics of substituting machines for manual operations, of choosing between machines for the same operation, and of replacing old machines with identical or supposedly better ones.

But plant layout and design are increasingly difficult to fix for any reasonable period of time. There must be technical and eco-

nomic flexibility. Material handling equipment, power and light distributions and machines cannot be rigidly specialized unless the immediate gains will rapidly absorb the recovery of capital. The product itself must be constantly redesigned under the economic-balance principle: *i.e.*, the optimum margin between the actual value of the utility produced and the cost of supplying it to the customer. In both the production of consumers goods and the specialized production of machines, the engineer must visualize the purchaser's economic problems as well as his own: to rationalize *all* of the factors in each situation.

There are, of course, many other fields pertinent to this discussion that I would like to explore, but neither my space nor your patience permit.

Engineers have ordinarily been restrained in their many aspirations by the cold necessity of proving the economic justification. They have been less scrutinized, perhaps, in the formulation of details within a project, although such details can often spell success or failure in subsequent performance. Of course, with some of the recent philosophies of government, a few have seen dreams come true in which they can build away to their heart's content, without the restraints of capital obtained by "the hard way." I do not feel particularly qualified to separate the good and bad projects that have galloped in all directions at once, but would like to make only one point. Once the "agency" of a problem is established, the engineer should be able to analyze, exhaustively and objectively, the economic reality contained therein, to a degree comparable to his purely technical ability. Many of the engineers I know confess and abhor their inability to get beyond an elementary level of arbitrary generality in economics.

It is expected, I am afraid, that I present specific opinion as to integrated courses that might implement the undergraduate mechanical engineer beyond the narrower band of conventional science. I suggest that for the isolated technical problems of practice, a course in Engineering Economy is of paramount importance, even above the descriptive course in social or political economy prescribed for most college students. For the larger problems of design and operation I might suggest such quantitative courses as: Power Economics, Economics of Industrial Costs, and Engineering Statistical Analysis. I am considering here only the basic tools that might find room in the curriculum.

When we get beyond the quantitative production aspects, we embrace the full sweep of general political economy. The engineer can perform most useful services in this field, as supplements rather than substitutes for the work of others. His scientific and

mathematical training should serve well in advancing rigorous, scientific method in testing some of the most tangible concepts. But there is futility in such endeavor unless he is willing to devote much time and intensive application to a very complex field that does not easily reduce to convenient parameters and mathematical equations. He can be assured that it will be a challenge to the highest professional ability that he can produce.

EXTENSION OF THE ENGINEERING CURRICULUM AND ITS RELATION TO COÖPERATIVE WORK *

By R. C. DISQUE

Dean of Engineering, Drexel Institute of Technology

Extension of the undergraduate curriculum has been a pious aspiration of engineering colleges for many years. So many attempts have been made to do this, and so obvious have been the failures, that it seems hardly worth while to discuss the question so far as it pertains to the conventional all-resident curriculum. In discussing the question, the second report of the Board of Investigation and Coördination sets forth the facts and gives its reason for the failure of five-year courses. The primary reason seems to be that "no efforts have been made to assure strong moral or material backing for these experiments from the engineering professions and industries." "Had these conditions been met," says the Board, "the outcome might have been different." But, in spite of the dubious prospect of success, proposals to extend the four-year curriculum to five years still seem to have an appeal in certain quarters; and, I take it, that the interest of coöperative colleges in these proposals lies in the implications for such colleges of a possible general adoption of five-year curricula by the all-resident colleges. In this paper I shall try to examine fundamentally the reasons for the failure of five-year courses and to point out methods by which the coöperative colleges can achieve the results hoped for from all-resident college courses but rarely, if ever, achieved.

If the engineering professions and industries have not lent moral and material support to five-year courses of the all-resident type, they must have had good reasons for their attitude. Certainly they have had time enough to appraise the product of the four-year courses and to adjust their attitude accordingly. What then can be the reasons for industry's indifference to five-year courses? In my view, industry has not recognized the advantages of five-year courses because those advantages do not, in general, exist in any substantial degree. I propose next to examine the reason for these conditions, to appraise the merits of the proposals for extending

* Presented at the 48th Annual Meeting, S. P. E. E. (Coöperative), Berkeley, Calif., June 24–28, 1940.

the curriculum and to show why, in my opinion, the coöperative courses hold out great promise of achieving the results usually hoped for from five-year all-resident courses.

Any proposal to extend the curriculum to five years must have one of three objectives: (1) to make room for more humanistic courses, (2) to strengthen and enrich the purely technical content, or (3) to adjust the student effectively to his post-graduate job.

Consider first the humanistic objective. To achieve the desired results in a five-year curriculum, liberal subjects can be concentrated in one year (usually the first year), or distributed through the five years. Few nowadays believe the former method to be effective. We know now that prefixing a typical liberal arts freshman year to the four-year engineering curriculum is relatively futile, because the desired results cannot be achieved by this method.

The second plan would be to distribute the liberal subjects through the five-year curriculum in a more or less continuous band. While this plan would seem to offer more promise than the other, it is nevertheless burdened with many practical difficulties and dubious expedients. Should all students pursue the same liberal sequence? Should they be given the choice among several sequences? Should they be allowed free election from one end to the other? The simplest policy would be to offer a single sequence and require all students to take it. That sequence would probably be in the social sciences. It would be easy to lay out on paper a good looking curriculum embodying these subjects. But, in any practical case, such a curriculum would not get much farther than this. Let anyone try to fit such a sequence of courses to any real situation! He will be faced with prohibitive complications. Assume a minimum of four engineering curricula with increasing divergence from the second year on. Three-hour laboratory courses, two-hour laboratory courses, lectures, quizzes, to say nothing of activity hours, are scattered over the hours of the day, and the days of the week. Suppose that common hours could be found for the engineering students, the next problem, almost as baffling, would be to fit them into the schedules of the non-engineering departments. If only one of those departments were involved, the case would be bad enough; but when several are concerned, it becomes impossible. To offer several humanistic sequences would only make matters worse.

But suppose these complicated problems could all be solved. What results could reasonably be expected? In some cases, no doubt, fair integration with the professional objective would be achieved. I am prepared to admit that some employers would give substantial recognition to these values, but not enough to persuade

the vast majority of students that the gain in either the long or short run would justify the extra cost of a five-year curriculum. The beginning salary scales are rather rigidly standardized, and seem to take no account of the value of humanistic sequences. Furthermore, I have seen no evidence to indicate that advancement in after life is closely correlated with them. In the words of the Board of Investigation and Coördination, "the success of five-year courses awaits more substantial recognition on the part of industry than we have yet seen." Industry is not to be criticized for this attitude; it knows what its needs are, and unless these needs are met, it cannot and will not change its attitude.

If the humanistic band could produce practical results by being closely related to the professional objectives, it would be amply justified, and I should be the first to favor it. But then it would be only an extension of the professional content, and would, in that character, cease to be liberal. But the fact seems to be that this cannot be done.

The second justification for extending the engineering curriculum to five years might be to strengthen and enrich the purely technical content. Does industry demand this? I think not. One rarely hears the criticism that engineering graduates are on the whole not well trained in technical subjects. The Board of Investigation and Coördination quotes the report of the National Industrial Conference Board Studies of 1924–25, which states as one of its deductions this: "As a general rule, the college men who followed after graduation the lines of their college training are satisfied with their technical and engineering courses, though some definitely indicated the lack of one or more particular courses which they believe would have been helpful in their industry, and all have done further studying." The report itself states on page 551: "There are few, if any, branches of higher education which are more severely tested by objective realities, nor are there any in which the content of curricula is more constantly and critically scrutinized for its relevance, in consequence of the rapid advance of knowledge and technical practice and the enforced limitations of time. The testimony of graduates, practitioners and employers gives ample support to the fundamental soundness of engineering education in its general plan, while indicating the need of many betterments of detail." The conclusion seems justified that the engineering curricula have been well conceived and ably administered so far as purely technical content is concerned. If this be true, four years would seem to be an adequate period for the attainment of these objectives. But this does not indicate that the content of the typical curriculum can be safely tampered with or reduced in order to introduce so called liberal courses of dubious value.

The third reason for lengthening the curriculum is to adjust the student quickly and effectively to his post-graduate job. This has been and still is the characteristic objective of the coöperative courses which have been almost universally extended to five years in order to achieve that objective. Whether or not these courses are all that their most enthusiastic adherents claim them to be, there can be no doubt that (1) they constitute the only five-year curricula that have attracted and held large numbers of students and (2) that they have succeeded in achieving their objective, in the opinion of those most qualified to judge, namely: the employers themselves. In its report on the Coöperative Method, the Board of Investigation and Coördination says: "Even with this reservation, however, it must be concluded, in general, that firms employing coöperative students endorse the plan as having educational merit. The fact that they continue coöperating after a fair trial of the plan substantiates this conclusion."

Experience has shown then, that the coöperative courses are the outstanding if not the only examples of success in extending the engineering curriculum to five years, so far, at least, as the major purposes of such extension are concerned. In my view, the cooperative courses can be used to do much more than this; they offer a golden opportunity to achieve the results hoped for and not yet attained by the five-year all-resident courses, particularly in the humanistic field, and this without impairing the technical curriculum in the slightest degree and without involving heavy expenditures of money.

This is the utilization of the industry period for independent study and reading—the next important advance in coöperative education. Any student could under competent guidance give himself a liberal education more valuable than that now acquired by most resident students in the liberal arts colleges. In fact, there are good reasons why a liberal education acquired in this way can be made superior to that attained in the liberal arts courses. It will readily be granted, I believe, that the distinctive mark of a liberal education is interest in a wide range of intellectual subjects. And the hall mark of the success of college courses in building the cultured way of life is the effect on the student's life after graduation. Does the graduate carry through life the habit of reading widely for pleasure? Is he hospitable to and sympathetic with new ideas in all fields of human endeavor? Does he try to understand beauty in all its forms? Is a degree in liberal arts a guarantee of a well adjusted cultural way of life? The available evidence on this point is unconvincing. Imagine a group of say, 100 people, some graduates of the leading colleges of the country,

say ten years out, others from small and obscure colleges, others not college graduates at all. Take note of their interests and aspirations, and on the basis of your observations try to identify the college graduates. Unless their conversation turns to athletics you will find great difficulty in doing so. As for identifying the colleges represented, that will, of course, be impossible. This is not to say that college does nothing for a man, but it does say that it does not do the thing we are talking about. Greater authorities that I have used stronger language than this in appraising the results of college education in these areas.

The fundamental difficulty lies, in my view, in the fact that colleges have lost their original objectives. College experience consists in passing courses; and not in building a way of life. Formal college courses do not succeed in establishing life habits because college life is too unlike post-graduate life. Even though the habits may have been developed in college, they do not in the majority of cases carry over into post-graduate life.

Now the characteristic merit of the coöperative plan is that it intensifies the similarities between college and past college experiences. For this reason it offers a more promising device for building enduring habits of independent reading and study than does the conventional form of college course. No doubt, deliberate efforts will have to be made by the faculty to insure success but such efforts should be relatively simple. They would consist, first of all, of a certain limited amount of promotional activity in compiling reading lists and in supervision. The cost of all this should be much less than that of conducting formal class room courses.

This constitutes, I believe, a great opportunity for the coöperative institutions. No better tribute of memory could be paid to the founder of coöperative engineering education than to enrich it by adding those values which are known to have been one of his major concerns; and it is my fervent hope that the coöperative institutions will assume the leadership in accomplishing these things.

IS YOUR ENGLISH SHORT-CIRCUITED?

By W. GEORGE CROUCH

Assistant Professor of English, University of Pittsburgh

AND

M. L. MANNING

Secretary, Educational Committee, and Research Engineer, Westinghouse E. & M. Co., Sharon, Pa.

Synopsis: The need of an adequate knowledge of English is often realized by the engineer only after he has been working in industry for several years. To meet this need, a post-graduate course in English—both written and oral—is suggested in this article.

Two questions are discussed in the light of what has been done during the past year in an English course given in the Transformer Division of the Westinghouse E. & M. Company, Sharon, Pa.: (1) What does the engineer need to know about English? (2) How may a course in English for graduate engineers be arranged to satisfy this need? A sound course in English for engineers is advocated to stimulate the interest of older, as well as younger, engineers in industry. A knowledge of the technique of the business letter, the engineering report, and the professional article is emphasized. The attainment of a rich and useful vocabulary by means of wide reading in scientific and humanistic articles and books is stressed. And the cultivation of effective oral English by much practice in public speaking is urged. The subject matter for such a course is discussed in detail and its concrete results are evaluated.

When the engineer has to face the problem of finding the cause for a short circuit in a piece of electrical apparatus, he makes a diagnosis of the trouble, attempts possible solutions, and provides protective measures. But that same engineer who has skill enough to solve a practical problem in short circuit analysis often finds himself baffled when he has to express in words his ideas about a transformer, a turbo-generator unit, or a spot welder. Yet the short circuit which has been set up in his mind because of his poor vocabulary or his lack of control over the tools of expression can be remedied by the application of methods just as logical as those which are used to solve engineering problems. The following article is an attempt by the authors to show what can be done about such a short circuit, one which is much less tangible than the short circuit in a piece of electrical equipment.

In the Transformer Division of the Westinghouse Company at Sharon, the minimizing of short circuits in language is being attempted by the establishment of a graduate course in written and oral English. This course has been arranged for older, as well as younger, engineers in the plant. It is given in coöperation with the highly successful University of Pittsburgh-Westinghouse Educational Program, which was first started in the Pittsburgh area in 1926. Since this particular course in English was not incorporated in the educational program of Westinghouse until the fall of 1939, it is somewhat in the experimental stage. Up to the present time, however, it seems to be sound fundamentally; and the experiment has proved exciting and valuable. What it has accomplished concretely may be judged by the following exposition of its purpose, the way that purpose has been carried out in practice, and the results which have been obtained.

As the first step, the authors investigated what had been done recently in the field of planning a two-semester (thirty two-hour sessions) course in English to fit the needs of practicing engineers. Existing courses, they found, are arranged chiefly for undergraduate students. Emphasis has not been placed on the group of experienced engineers who were graduated from colleges ten or more years ago. Commendable papers on the general subject of English for engineers are listed in the references (1), (2), (3), (4), (5).

Since the field has been comparatively unexplored, the authors felt that they should consider two significant questions concerning English for graduate engineers: (1) What does the graduate engineer need to know about English? (2) How may a course in English for graduate engineers be arranged to satisfy this need?

In answering question one, the type of writing done by engineers in the Westinghouse Plant in Sharon was analyzed. This analysis revealed that the engineers in the plant had to handle correspondence with district offices and customers, write specifications and contracts, inspection and test reports, instruction books and leaflets, and engineering reports. Furthermore, many of them had to give instructions to the Shop and the Test Department in non-technical language, and quite a few were requested to give talks to townsfolk on various phases of their work in the Company.

These duties meant that they would have to have as thorough a command of language as a tool for communication as they would of the technical details of the design of transformers. In other words, they would have to express themselves in language that would be dynamic, clear, simple, and purposeful—language which would prevent the occurrence of short circuits in thought.

Short Circuit Analysis

1. *Faults in Business Correspondence* (Time allotted: 6 weeks)

As the first type of short circuit to be considered in the course, the common faults that creep into business correspondence were chosen. In order to relate the business letter to the work done by engineers in the plant, copies of actual letters sent out by the Westinghouse engineers were obtained and used as laboratory specimens. These letters related to district offices, the Sales Department, and interworks correspondence. They were analyzed and discussed in the classroom from the standpoint of layout, plan, and expression.

The form of the letters was particularly stressed. Each student was made acquainted with stationery prescribed by the Westinghouse Company, and the requirements for letters sent to the various branches of the Company and to outside organizations. Attention was drawn to block, semi-block, indented, and military styles. The varying degrees of formality in types of salutation and complimentary close were also pointed out.

Special importance was attached to the analysis of the purpose of the letter, and students were given practice in the writing of order letters, letters of inquiry, sales letters, letters of instruction, letters of transmittal to accompany engineering reports, and letters describing various pieces of apparatus and technical procedures.

To make this type of work applicable to the correspondence of the Westinghouse Company, a bulletin published by the Westinghouse Industrial Relations Department, "Our Letters," was used to supplement regular assignments in the textbook (6), "A Manual of English for Engineers," by Sypherd and Brown. "Our Letters" aims to improve business relations between the Westinghouse Company and its customers, and gives in each issue sample letters as well as pointed advice concerning the standards which the Westinghouse Company wishes its employees to follow in their correspondence. The bulletin was especially useful in making emphatic the points brought out in the classroom.

In addition, a study was made of the trite expressions which are sprinkled throughout letters by the careless writer. The purpose of this part of the course was to have the student cultivate originality of expression, so that his diction would have freshness and vitality. Since so many flowers of expression wither before they come to maturity, each student was advised to cultivate his garden of ideas in his own way. Individuality of expression was the ideal striven for. Needless to say, the blue pencil was used rigorously in the correction of every letter written outside of class, and each student

received personal comment of a constructive kind when his corrected paper was returned. Students were urged to bring in letters which had been written in the office, so that such letters could be criticized on the basis of the principles taught in the classroom.

To complete the discussion of this first type of short circuit, several class meetings were devoted to the principles of dictation. At the beginning of each session, students were given letters which had been written in the various departments of the Westinghouse Company. Each student was assigned a letter which had been written in his department. After he had had an opportunity to study its contents for a few minutes and to make mental notes concerning the points to be taken up in the answer, he was asked to stand before the class and dictate his reply. Two stenographers came to each class meeting and made shorthand transcripts of each letter. These letters were transcribed and typed, criticized by the instructor at the next meeting of the class, and handed back to the student.

One of the most helpful teaching devices related to this part of the course was specific criticism of letters placed on the blackboard. Before each class session, the instructor made a thorough analysis of the faults occurring in the letters which had been written by the students during the previous week. Errors were tabulated according to their frequency of occurrence, placed on the blackboard, and discussed by the entire class. Remedies for each error were suggested. As a result, these concrete examples helped to make the writing of virile sentences and the correct use of grammatical forms habitual.

2. *Flaws in the Engineering Report* (Time allotted: 6 weeks)

The second type of short circuit considered in the course was that which occurs in the engineering report. Poor organization, lack of clarity, conciseness, and accuracy, and failure to interpret data intelligently are the contributing factors in a short circuit of this kind.

This part of the work was made as practical as possible. Standards published by the A. I. E. E. were made the basis for discussion, and reports actually written in the Westinghouse plant by the engineers in the class were handed to the instructor for constructive criticism.

Special emphasis was placed on the method for tracking down bibliography relating to various subjects in the field of electrical engineering, on the proper recording of bibliographical items, and on the sifting of bibliographical items so as to form a working bibliography. Efficient ways of taking notes were outlined, after which

stress was placed on the analysis and interpretation of the data which had been gathered. Various forms of outlines were demonstrated, as well as the methods of exposition which would prove most effective in transforming the outline into a smooth and clear report.

Since the engineer needs to cultivate a business-like, crystal-clear style, one which will make the communication of his ideas to others easy and effective, these qualities were set before the class by the examination and analysis of various types of published engineering reports. The distinctions between the progress, the periodic, the examination, and the research report were explained and demonstrated concretely. The use of graphs and diagrams and simple illustrations involving fundamental engineering principles was encouraged in order that the engineer might present his material as vividly as possible. The order of the report followed the plan approved for engineering reports by officials of the Westinghouse Company.

3. *Defects in the Writing and the Presentation of Technical Papers*
(Time allotted: 6 weeks)

The study of the third type of short circuit was a diagnosis of the weaknesses commonly found in technical papers. Editors of technical journals most often complain that authors are too verbose in presenting their material, too hackneyed in the expression of their ideas, and too oblivious to the interests of their readers. Moreover, when technical men present their papers orally before audiences they are likely to fall prey to all the faults of poor public speakers: mumbling, indistinct enunciation, improper emphasis on important ideas, lack of enthusiasm, academic dryness, unintelligent phrasing, and a rate of speaking which prevents clear reception of ideas.

Besides the elimination of these weaknesses, the students in the class were encouraged to present papers at the meetings of the A. I. E. E. or to prepare papers for publication in the various journals. It was stressed that the contemporary engineer has an obligation to publish the results of laboratory work which may prove of special interest to the members of his profession. Unfortunately, many engineers are unable to attend professional meetings. The necessity of staying on their jobs often precludes their journeying long distances to these meetings. Instead, engineers have to rely upon the published papers of others for stimulation to conduct their own research and to gain new ideas.

Accordingly, each member of the class was urged to publish articles as often as possible. As preparation, experimental papers

were attempted by the group. The subjects chosen related to the interests of the students and were prepared according to the standards set by the A. I. E. E. in its pamphlet "Preparation of Manuscripts: Suggestions to Authors" (1938). The members of the class were encouraged to pay particular attention to the style used by the writers of technical articles accepted by the A. I. E. E. Each student was urged to make his article brief and succinct, since budget limitations for publication must always be considered. Brevity, consistent with completeness and high quality, was the ideal set before each man.

4. *Limitations in Vocabulary* (Time allotted: 4 weeks)

Limitations in vocabulary constituted the fourth type of short circuit. These limitations were not corrected by four weeks of concentrated reading. Instead, the study was spread throughout the year. Each week the student was asked to read specific essays in the volume (7) "Essays in Science and Engineering" by Montgomery and Becklund. He was instructed to make a list of all words which were new to him and to consult a good standard dictionary for accurate definitions of these words. Throughout the course, the content of the essays was discussed in class. As a supplement to this discussion, the etymology of the most interesting words found in the essays was placed on the board. An attempt was made to show the romance which is inherent in the English vocabulary. This part of the work included stress on accuracy, variety, and freshness in diction; the proper use of words; recognition of key words in reading; and the making of mental pictures of words as symbols for emotions, feelings, and ideas.

More than ever before, the keynote of engineering training is to make the engineer realize his place in contemporary society and to make him aware of his social responsibility as a man as well as a technician. Such essays as H. F. Moore's "Engineering Culture," Karl T. Compton's "Engineering in an American Program for Social Progress," and Ralph E. Flanders's "The Engineer in a Changing World" direct the attention of the engineer to the ways by which he may be of use in a world which needs his efforts to help overcome the ills of present-day society. These essays, and many others of like kind and quality, formed the reading pabulum of the course. Their stimulating points of view, it is hoped, helped to sharpen the intellectual curiosity and to deepen the appreciation of each engineer concerning his place in a complex social order.

5. *"Burn-Outs" in Public Speaking* (Time allotted: 8 weeks)

Although an engineer may be able to write effectively, he often finds himself groping for words or for the technique of expression when he has to explain his ideas to an audience. As "burn-outs" result from short circuits in electrical apparatus, so this type of speaker is a "burn-out" to his audience. They squirm as they listen to his stammering, uncertain delivery, as they feel the lack of any personal feeling behind his words, as they strive to follow a train of thought which is as pale as a faded morning glory.

The importance of combining work in speech with written work is becoming more apparent as the duties of the engineer place him more and more before the public. Each day he is forced to defend what he is doing and to define the meaning of his work in terms of the layman. Whether he has to explain the lightning surge test before a group of visitors to the plant or has to justify his plan of action before a group of his superiors or customers, he cannot afford to be short-circuited by lack of an adequate choice of words, by failure to organize his ideas quickly and effectively, by inability to speak fluently and without embarrassment, or by ignorance of his audience, its desires and its interests.

To avoid "burn-outs," simple problems relating to work in the Westinghouse plant were assigned at first. Engineers were asked to explain in non-technical language subjects like the following: "What is a transformer?"; "Distinguish between a shell and a core form transformer"; "Why is inerteen sometimes used in transformers instead of oil?"; "What is a de-ion gap?"; "How does the initial voltage distribution compare in shell and core form transformers?"

Such an assignment was preceded by instructions concerning how to adapt material to the understanding of an audience, how to gain the attention of audiences by appealing to their basic interests, how to talk with a keen regard to the response of hearers. The whole technique of organizing a talk was placed in the form of a chart on the blackboard. The central purpose of a speech was considered, with its analysis into main parts and its appeal to an audience by means of concrete examples, deft use of graphs, charts, or statistics, devices such as comparison of the known with the unknown, citation of expert opinion, and employment of a variety of expository methods to make plain the speaker's message.

In particular, the conversational style of delivery was set up as the standard to be striven for. Speaking with a sense of communication, keeping the mind fixed on important ideas, and full realization of the content of words on the part of the speaker were illustrated and put into practice. Class work included a discussion of

the presentation of papers before learned societies. An excellent text (8) for this type of work is S. Marion Tucker's "Public Speaking for Technical Men."

Fortunately, the Westinghouse auditorium in the plant in Sharon is equipped for the showing of talking pictures. Full use of this educational medium was made by the demonstration of the principles of good speaking as illustrated in films which the Industrial Relations Department of Westinghouse used for the instruction of the sales force of the Company. The films shown concerned the organization of talks, the use of the voice in speaking, and the ways of making talks interesting to audiences. They formed a useful supplement to the class lectures and to the speeches delivered by the members of the class.

It must be understood that this unit of the course was in no way a "road-to-success-in-eight-easy-lessons" type of instruction. The authors realize only too well that good public speakers cannot be trained in eight weeks. They need much practice and long hours for preparation. If the course were repeated, it might be well to devote one full term to speech work. The brief time spent on the subject did serve to point out to each man his defects and his strength as a speaker, to give him some practice, and to stimulate him to seize every opportunity afforded him outside the classroom for making speeches and putting the principles of good public speaking into active operation.

Tangible Accomplishments

In spite of the fact that the course in English which has been outlined above was given to engineers immediately after they had completed a full working day, interest was exceptionally alive. The mere fact that the work was different from what the students had been doing all day helped to solve the problem of catching and holding the attention of the group.

One may well ask just what such a course has accomplished. In the first place, it has made the engineers in the class conscious of the kind of English which they use. Many of the engineers have said that in their dictating of letters they are reminded of the points brought out in class concerning the standards of a good business letter. They are especially conscious of the need for the "you" attitude and of the expression of this attitude in appropriate words. In their dictation, they take more time in the preparation of what they want to say in order to obtain clarity and unity. They aim to make the tone of their correspondence conversational yet dignified, with the proper attention given to the service element.

SUMMARY

Is Your English Short-Circuited?

What—Lack of Control Over Tools of Expression
Where—In the Mind of the Engineer
When—Daily Work
How Minimized—Sound Graduate Course in Written and Oral English

Circuit Analysis			Protective Methods Used to Minimize Short Circuits
Type of Circuit	Time Allotted (Weeks)	Component Parts of Circuit	
1. Business Correspondence	6	1. Types of Letters Instruction Letters Inquiry Letters Transmittal Letters Sales Letters Interworks Letters District Office Letters	1. Use of actual correspondence letters. 2. Analysis of letters for layout, plan, purpose and expression. 3. Style of letter—block, semi-block, indented, military. 4. Study of trite expressions. 5. Emphasis on individuality of expression.
		2. Dictation	1. Practical application of the principles of letter writing. 2. Students assigned letters written in their departments. 3. Replies dictated in class. 4. Specific criticism of letters placed on blackboard. Remedies for each error suggested.
2. The Engineering Report	6	Kinds of Reports 1. Progress 2. Periodic 3. Examination 4. Research	1. Concrete distinction between kinds. 2. Use of standards published by the A. I. E. E. and by the Westinghouse Company. 3. Efficient note taking. 4. Analysis and interpretation of data gathered. 5. Recording of bibliographical items. 6. Use of diagrams, graphs and charts.

SUMMARY—Continued

5. Recording of bibliographical items.
6. Use of diagrams, graphs and charts.

SUMMARY—Continued

Circuit Analysis			Protective Methods Used to Minimize Short Circuits
Type of Circuit	Time Allotted (Weeks)	Component Parts of Circuit	
3. The writing and the presentation of technical papers	6	1. Preparation and presentation of papers at A. I. E. E. meetings and other technical groups. 2. Engineer obligated to publish results of work. 3. Majority of engineers rely upon published papers for stimulation. 4. Budget limitations, a major item for the publication of technical papers.	1. Experimental papers written by class. 2. Subjects chosen related to interests of class. 3. Particular attention to standards set by the A. I. E. E. 4. Brevity with completeness emphasized.
4. Vocabulary	4	1. Insufficient attention to reading and use of the dictionary. 2. Lack of an adequate choice of words.	1. Study spread out over year—not localized by concentrated 4 weeks of study. 2. Reading of specific essays. 3. Test for new words—use of dictionary, etymology. 4. Recognition of key words—mental pictures. 5. Stress upon social responsibility.
5. Public Speaking	8	1. Failure to organize ideas quickly and effectively. 2. Explanation of technical subjects in non-technical language. 3. Inability to speak without embarrassment and fluently. 4. Discussion of the papers presented before Societies.	1. Combination of speech with written work. 2. Adaptation of material to the audience. (*a*) How to gain attention. (*b*) How to talk. 3. Organization of a talk. (*a*) Appeal to audience by graphs, charts, and various devices. (*b*) Analysis into main parts. 4. Conversational style of delivery. 5. Demonstration of the principles of public speaking by use of films.

Practice before the class has made each man more self-critical and has led to the formation of correct habits.

In the second place, the engineers in the group testify to the fact that they have a better understanding of the types of engineering reports than they did before they enrolled in the course, and that the purpose and the requirements of a good report are more definite in their minds. They are particularly appreciative of the criticism which they have received on the reports. Much the same comment has filtered in concerning the writing of technical articles.

In the third place, the engineers have found the vocabulary drills helpful in enlarging their stock of words and in making them more exact in the use of language. They are cultivating the habit of reading with a dictionary at hand and of using the dictionary intelligently, of looking up the derivation of words, of reading critically and noting the points of style used by the best writers in their field, and of forming better reading habits.

In the fourth place, the engineers have improved their speaking a great deal. Their organization of material is firmer, their methods of supporting their points are varied, and their approach to the interests of an audience is psychologically sound. They are able to keep talks alive throughout the period they are on the floor and are able to back up their specific illustrations with an appropriate appeal for action at the end of the speech or with a smooth rounding out of their main purpose.

The authors make no claims to infallibility. The course as outlined is open to many objections and no doubt needs some revision. At the outset of this article, the experimental nature of such a course was brought to the attention of the reader. On the testimony of the students in the course, however, the general plan of study has proved its worth.

Acknowledgment

The authors acknowledge the helpful assistance given by Messrs. W. M. Dann and W. L. Teague of the Westinghouse Electric & Manufacturing Company.

References

1. C. W. Dunham, "English in Engineering Education," *Electrical Engineering*, Vol. 56, April, 1937.
2. J. R. Manning, "Scientists Must Achieve Power of Expression," *Journal of Chemical Education*, June, 1939.
3. W. O. Sypherd, "Thirty Years of Teaching English to Engineers," Journal of Engineering Education, Oct., 1939.

4. W. W. PALMER, "The Importance of English to an Engineer," *The Electric Journal*, Vol. 34, Feb., 1937.
5. C. F. KETTERING, "An Engineer's English," THE JOURNAL OF ENGINEERING EDUCATION, Jan., 1937.
6. W. O. SYPHERD AND SHARON BROWN, "A Manual of English for Engineers," New York: Scott Foresman and Company, 1933.
7. F. MONTGOMERY AND L. N. BECKLUND, "Essays in Science and Engineering," New York: Farrar and Rinehart, 1938.
8. S. MARION TUCKER, "Public Speaking for Technical Men," New York: McGraw-Hill, 1939.

SECTIONS AND BRANCHES

"Developments in the Engineering Defense Training Program" was the topic discussed by Dean A. A. Potter before a meeting of the **Purdue Branch** of the Society on March 19.

The purpose of the training program and its relationship to engineering schools and their regular curricula was mentioned along with some interesting statistical data on the number of students enrolled, number of different courses, and their duration, for Indiana and for the nation as a whole.

The requirements of the Army, Navy, Federal Civil Service, and manufacturing industries for technically trained men, and the way in which the training program attempts to meet these needs, were outlined.

The answers to some questions regarding selective military service and its probable effect upon engineering schools, engineering students, and recent graduates were of particular interest to the group.

J. N. ARNOLD,
Secretary

LETTER TO THE EDITOR

Dear Professor Bishop:

It has occurred to me that it might be helpful to many of our members if you were to publish in each issue of ENGINEERING EDUCATION a listing of the forthcoming section meetings of the society and their locations. This might be located on the back of the Table of Contents page below the list of the National Officers of the Society. My reason for making this suggestion is that with so many members away from their homes for National Defense and

other reasons, they might be interested in learning the dates and locations of the section meetings in their district. Since in many cases the secretary of a section has no idea of how many transient members are in his section district, this is the only way they would receive any advance notice of the meeting. Those particularly interested in procuring a copy of the program in advance could doubtless obtain it by writing to the secretary.

As I think I have already written you, the New England Section is to hold its Fall Meeting on October 18, 1941, at the Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H.

Sincerely yours,

CARLTON E. TUCKER

Will you furnish the Secretary's office with the place and dates of your Section meetings so that a list of such dates may be compiled and printed on the page immediately following the table of contents in each issue of the JOURNAL OF ENGINEERING EDUCATION?

F. L. BISHOP,
Secretary

ENGINEERING ECONOMY PAGE

Engineering Economy deals with comparisons between technical alternatives in which the differences between the alternatives are expressed as far as practicable in money terms.

EUGENE L. GRANT, Stanford University, *Editor*

USING LOCAL PROBLEMS IN THE COURSE IN ENGINEERING ECONOMY

The following extract from the stenographic report of the panel discussion held at the 1939 Annual Meeting describes an effective teaching device.

D. B. PRENTICE (Rose Polytechnic Institute): Mr. Chairman, in connection with stimulating student interest, I think reference to some spectacular engineering structure or machine catches their interest right away. It so happens that about a mile from our campus is the largest electrical shovel in the world on strip operation. It represents an investment of half a million dollars in one piece of machinery, and just presenting that to them as a problem, makes it interesting for them. How in the world is the mining company ever going to get back its investment? Giving them information about the depth of the overburden, the average thickness of the seam, and so on, dramatizes the cost idea or the "will it pay?" idea for them.

J. C. G. SEIDL (Manhattan College): Naturally we have many good local problems in New York City. The Henry Hudson Bridge over the Spuyten Duyvil Creek gave me a grand chance to send the boys down there to do their traffic counts and report on the economy of that particular bridge. Before it was erected we compared the economy of a one-deck and a two-deck bridge. After one-deck was built and the traffic grew rapidly we had the problem, "shall we put on another deck or widen it?"

CHAIRMAN F. H. CRABTREE (Tufts College): You don't have to have an elaborate set-up, though, to get an interesting problem. I gave the boys the papers that I had on an easy-payment plan from one of the automobile companies, one of the automobiles I bought before I took the course in Engineering Economy (laughter), one of those things where you pay a small fee so that they can investigate you, and then six per cent, I believe was the interest rate, or so they said. I believe it figured out nearer thirty-six per cent when the boys got through figuring it (laughter). I think there was quite a bit of interest in that, perhaps because they liked to show me up.

C. I. MILLARD (Cornell University): I require a term report on some local problem on which the students can collect their own data. For instance, one of my good ones pertained to the publications on the campus. It seems that there are twelve or thirteen publications, using rented office space and rented equipment and scattered all over the town. The proposal was that these publications all be brought together under one roof, equipment purchased, and all work done in that one building. The students obtained the cost under the present system and they also obtained the cost under the proposed system, even going so far as to design the building, laying out the floors and offices, and obtaining costs on the various equipment necessary. The result was a considerable saving in favor of the one building. It was a report of sufficient value that it could be turned over to the proper authorities and say "why don't you do this?"

DIVISION OF INDUSTRIAL ENGINEERING

The proposed constitution of the Division was presented in the April issue of the JOURNAL.

In accordance with Article VI of the proposed constitution the chairman has appointed the following nominating committee:

Chairman, Paul T. Norton, Jr., Virginia Polytechnic Institute.
J. R. Bangs, Cornell University.
C. A. Koepke, University of Minnesota.

They have submitted the following report:

L. P. Alford, New York University.
E. D. Ayres, University of Wisconsin.
R. M. Barnes, University of Iowa.
G. W. Barnwell, Stevens Institute.
C. L. Eddy, Case School of Applied Science.
A. S. Knowles, Northeastern University.
P. N. Lehoesky, Ohio State University.
H. G. Thuesen, Oklahoma A. & M.

Since this is the first election and since the constitution calls for a term of two years, the following suggestion was made by the nominating committee:

"The four men receiving the largest number of votes become members of the Executive Committee and that of these four the two receiving the highest number of votes be the ones elected for the two year term, and those two receiving the lowest vote be elected for a one year term."

It is understood that nominations in addition to those made by the nominating committee may be made from the floor at the time of the election which will be at a dinner meeting on Wednesday evening June 25.

C. E. BULLINGER,
Chairman

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

B. M. GREEN, *Editor*, Stanford University

MID-YEAR MEETING OF THE DIVISION

The second mid-year meeting of the Drawing Division was held in St. Louis, Mo., on February 22, under the auspices of Washington University. In attendance were representatives from seventeen schools and colleges distributed from New Jersey to Texas.

In the morning the executive committee put in three full hours preparing an outline for the June meeting at Ann Arbor, the preliminary results of which were published on this page in the April issue. All members of the committee, except one, were present as well as many other members of the division who arrived early.

The programs for the afternoon and evening sessions were prepared and presented under the direction of Dean A. S. Langsdorf, Professor F. W. Bubb and Mr. Bockhorst, all of Washington University. At the afternoon session, Mr. Robert Washburne, Chief Lofter of the Curtiss-Wright Corporation, presented a paper on "Lofting Practice in the Airplane Industry," illustrated by blackboard sketches and full size examples of the work performed on the loft floor. Discussion brought out the extreme accuracy of the work and the many applications of descriptive geometry.

A second paper on "Military Uses of Aerial Photographs" by Capt. R. R. Arnold, U. S. Engineer Corps, was read by Professor Heacock, Capt. Arnold having been called away on military duty.

Dean Langsdorf presided at the evening dinner session which was attended by fifty-eight division members and teachers of drawing in the technical high schools of St. Louis. Mr. Roland W. Bockhorst gave an illustrated talk on "Camera Aids in Lofting Technique" which supplemented in an excellent manner the discussion at the afternoon session. A brief discussion of the proposed National Study of Engineering Drawing, presented by Dr. C. V. Mann followed by a preview of the program for the June meeting concluded the dinner session and brought to a close a most stimulating conference.

NATIONAL DRAWING COMPETITION

The Committee is anxious to have a large representation of competitive drawings at the annual meeting. The General Regulations were given on this page in the January issue. An entry fee of one dollar is required to cover mailing and problem costs. If you have not received the problems and specifications they will be mailed on application to the Competition Chairman.

The Committee wishes to compile a list of criticisms and suggestions for the benefit of future competitions. Your assistance in this respect will be appreciated.

NEW MEMBERS

ARNETT, LAWRENCE C., Instructor in Electrical Engineering, Howard University, Washington, D. C. A. E. Richmond, D. E. Howard.

EDGECOMB, REX E., Instructor in Engineering Mechanics, University of Nebraska, Lincoln, Nebr. W. L. DeBaufre, T. T. Aakhus, J. W. Haney.

EGRY, CHARLES R., Associate Professor of Mechanical Engineering, University of Notre Dame, Notre Dame, Ind. W. L. Shilts, F. W. Horan.

ERMENC, JOSEPH J., Instructor in Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. G. K. Palsgrove, E. A. Fessenden.

GILLAN, GERALD K., Instructor in Civil Engineering, University of Missouri, Columbia, Mo. Harry Rubey, R. B. B. Moorman.

GROSSER, WILFRED R., Instructor in Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. E. F. Church, F. W. Ming.

GUERNSEY, ROSCOE, Instructor in Civil Engineering, University of Texas, Austin, Texas. P. M. Ferguson, H. E. Degler.

HERTEL, KENNETH L., Professor of Physics, University of Tennessee, Knoxville, Tenn. R. M. Boarts, R. W. Morton.

HOWELL, ALVIN H., Assistant Professor of Electrical Engineering, Tufts College, Medford, Mass. E. MacNaughton, W. E. Farnham.

HYDEMAN, WILLIAM R., Instructor in Mathematics, Norwich University, Northfield, Vt. A. D. Taylor, A. E. Winslow.

LEE, GEORGE H., Instructor in Mechanics, Carnegie Institute of Technology, Pittsburgh, Pa. W. N. Jones, F. M. McCullough.

MANGOLD, JOHN F., Associate Professor of Mechanics, Illinois Institute of Technology, Chicago, Ill. S. F. Bibb, W. H. Seegrist.

NEEDHAM, C. E., President, New Mexico School of Mines, Socorro, N. M. S. R. Talmage, J. W. Kidd.

PAUSTIAN, JOHN, Instructor in Mechanics, University of Nebraska, Lincoln, Nebr. O. J. Ferguson, J. W. Haney.

RUGGLES, EDWARD W., Director, College Extension Division, North Carolina State College, Raleigh, N. C. B. R. Van Leer, F. W. Lancaster.

SCOTT, ERMAN O., Assistant Professor of Civil Engineering and Engineering Mechanics, University of Toledo, Toledo, Ohio. D. M. Palmer, J. B. Brandeberry.

WAKEFIELD, ERNEST H., Instructor in Electrical Engineering, University of Tennessee, Knoxville, Tenn. R. W. Morton, R. M. Boarts.

WILLIAMS, ROBERT D., Associate in Mechanical Engineering, University of Illinois, Urbana, Ill. C. J. Starr, C. H. Casberg.

ACTIVE INSTITUTIONAL MEMBERSHIP: UNIVERSITY OF ALASKA, College, Alaska. W. E. Duckering, Dean.

211 individual members + 2 institutional members this year.

NECROLOGY

It is with deep regret that I have to inform you that R. E. Nyswander, Dean of the School of Science and Engineering, died on April 8, 1941. Dr. Nyswander became a member of the Society in 1912.

He was born January 4, 1878, in Antwerp, Ohio. He graduated from the University of Indiana in 1901 and received a master's degree from Indiana and the doctor of philosophy degree from Cornell. He joined the faculty of the University of Denver in 1909 as instructor in physics. In 1919 he established the Department of Electrical Engineering. He became associate dean of the School of Science and Engineering in 1931 and rose to the position of Dean in 1937. His work in experimental physics included pioneering study of infrared rays and radioactivity. He was a member of the American Institute of Electrical Engineers.

BOOK REVIEWS

Cofferdams—First edition. LAZARUS WHITE AND EDMUND ASTLEY PRENTIS. Columbia University Press, New York, 1940. 273 pages, 176 illustrations. $7.50.

The dearth of conclusive literature on the subject of scientific cofferdam design prompted these two seasoned construction engineers to write this volume. Their many experiences while contractors engaged in the channelization of the upper Mississippi River are herein shared with the remainder of the profession. Actively engaged during the last ten years on this $200,000,000 program. They have had an ideal opportunity for large scale laboratory testing. Deductions from the observations and records of these tests have resulted in a justifiable questioning of some of the present cure all methods of analysis.

The authors have followed closely the logical pattern of their book "Underpinning" in presenting the material. First, the theoretical aspects of the seepage of water into the cofferdam, erosion control, and lateral earth pressures are discussed. Next the practical considerations covering such subjects as preliminary investigations, stages in construction, flood protection, and other pertinent

features are explained. The last 120 pages are the meat of the book. The various types of cofferdams are presented in the section with pleasing thoroughness. Also included is a glossary of terms, an appendix of wages of costs, and a comprehensive bibliography of recent cofferdam literature.

For student engineers the book presents a clear readable story of cofferdams, the details of their design, and features of their construction.

As a reference for teachers presenting this subject or men engaged in this type of construction it should be listed as a *must* book.

ALFRED ACKENHEIL

Analytical Mechanics for Engineers. SEELY AND ENSIGN. John Wiley and Sons.

The subject matter of elementary engineering mechanics changes very little over a period of time, hence a revision of a mechanics textbook usually means a rearrangement of the material and the addition of a number of new problems. There are two reasons for such a revision. First, the instructor welcomes this means of changing his course from time to time and second, it is well at intervals, to confront the students with a new list of problems, especially in a course such as this which depends largely on the application of the fundamental principles developed in the text.

This standard textbook by Professors Seely and Ensign has become well known since its first publication. In this, the third edition, the more elementary material has been shortened somewhat to make room for other subjects. A chapter on mechanical vibrations has been added to Part IV, headed Special Topics, and which deals with the more advanced subjects. The discussion of Coriolis' Law has been moved from Part II—Kinematics, to Part IV and hence may be conveniently omitted in the more elementary courses. The list of problems including examples, has been expanded from 850 to 1,037 and includes many new ones. Also, throughout the book, the practical and important matter of variable forces has been treated with more emphasis.

T. G. BECKWITH

G-E Campus News

JUNGLE JIVE

MISSIONARIES working among a newly discovered tribe of savages in Netherlands, New Guinea, which has many times been called one of the "earth's remotest spots," had a strange experience.

They invited natives into their bamboo hut and turned on their short-wave radio. The tribesmen looked at one another in frightened amazement. Rev. C. Russell Deibler, one of the missionaries, says this of what happened: "As they heard voices coming from the receiver, they crouched over close and jabbered back, utterly bewildered where the strange voice was coming from."

The missionaries wrote their experience in a letter to Station KGEI, G.E.'s short-wave station in San Francisco, which sends its radio signal into Asia, using special directional antennas.

SPIDERCRAFT

COULD you spot-weld wire one-quarter as thick as a human hair?

That's the problem G-E engineers faced in producing filaments for thermocouples, those little super-sensitive devices used in measuring high-frequency alternating currents or voltages. These dainty filaments are 1/2000 of an inch in diameter—so

small that they are almost invisible—and have to be welded into a "K" shape.

The work is so fine that it must be done under a microscope, using a pair of tweezers to hold the wires.

At Schenectady there's a whole section of the G-E Industrial Department devoted entirely to welding. Practically all the men in this section are graduates of the G-E Test Course. General Electric Company, Schenectady, N. Y.

GENERAL ELECTRIC

660-20-211

A COMPLETE PRINTING SERVICE . . .

GOOD PRINTING does not just happen; it is the result of careful planning. The knowledge of our craftsmen, who for many years have been handling details of composition, printing and binding, is at your disposal. For over sixty years we have been printers of scientific and technical journals, books, theses, dissertations and works in foreign languages. Consult us about your next job.

PRINTERS OF THE
JOURNAL OF ENGINEERING EDUCATION

LANCASTER PRESS, Inc.

PRINTERS . BINDERS . ELECTROTYPERS

ESTABLISHED 1877 LANCASTER, PA.

New Engineering Textbooks

DESIGN OF MACHINE ELEMENTS *By V. M. Faires*

The new thoroughly revised edition of this popular text gives a clear, full treatment of modern design procedures and materials for all common machine elements. 450 illus. $4.00
The Problem Book by Faires and Wingren has been revised to accompany the new edition of the text. $1.40

For courses in Machine Design

DESIGN OF MODERN STEEL STRUCTURES
By Linton E. Grinter

This volume completes the author's excellent series of textbooks on structures. The first two volumes on theory are already being widely used. This book covers very fully the design, in both steel and timber, of office and industrial buildings and bridges. It includes a large number of very carefully worked out problems. 330 illus. May. $5.00 (probable)

For courses in Structures

ENGINEERING KINEMATICS *By Alvin Sloane*

This new text treats the elements of mechanism such as cams, gears, etc., as illustrations of the principles of displacement, velocity and acceleration, thus giving the student a thorough understanding of the fundamentals common to all moving parts of machines, and a clearer understanding of the parts themselves. 327 illus. $4.00

For courses in Mechanism

TECHNICAL LETTERING
By E. P. DeGarmo & F. Jonassen

This new manual uses a new device—alternating pages of text and tracing paper—to simplify both the learning and teaching of lettering. Clearprint paper and spiral binding add to its effectiveness. May. $1.00 (probable)

For courses in Lettering

The Macmillan Company, 60 Fifth Avenue, New York

In Preparation

Highway Economics

by HARRY TUCKER, Professor of Highway Engineering and Director of Engineering Experimental Station
and MARC C. LEAGER, Professor of Statistics and Accounting;
both men of the North Carolina State College of Agriculture and Engineering of the University of North Carolina.

An "International Text in Civil Engineering"

Need for such a book long felt

Highway engineers and economists have hesitated to prepare such a book because of lack of data. Now, authors Tucker and Leager have prepared basic factual information on highway economics disclosed by recent highway planning surveys in a number of states, by research projects undertaken by highway organizations and other agencies, and by investigation of the Public Roads Administration and the Federal Coordinator of Transportation. This new book is intended for students of highway engineering and also for others who have an interest in the economics of highways. It is an outstanding piece of work in the diversity of subjects treated and the simplicity of presentation. **HIGHWAY ECONOMICS is now in the process of manufacture with the intent of publication during the summer.**

An Introduction to the Operational Calculus

by WALTER J. SEELEY, Chairman, Department of Electrical Engineering, Duke University

An "International Text in Electrical Engineering"

Gives a working knowledge of subject

This new book presents some of the methods of the operational calculus for the use of engineering undergraduates whose mathematical equipment is necessarily limited, and for practicing engineers whose mathematical equipment has become rusty through disuse. These methods are prepared in a gradual and smooth development, proceeding by easy steps from known mathematical processes to newer ideas and methods. The operational calculus as developed in this book is merely a shorthand method of solving certain types of differential equations, is based upon, and developed from, the classical methods of solving these equations. Transition from the classical to the operational calculus is so gradual that the student hardly is aware he has advanced into another mathematical realm. **This new book is also in the process of manufacture with the intent of publication during the summer.**

***Ready Soon*—Order Examination Copies In Advance**

International Textbook Company
Scranton, Pennsylvania